Saskatchewan
Agriculture
and Food

FINAL REPORT

Agriculture Research Branch
Saskatchewan Agriculture and Food

19980181

CENTRE FOR PRECISION FARMING

Funded by
Technology Adoption Demonstration

March 2002
Prepared by: Indian Head Agriculture Research Centre

102-04968/

Table of Contents

Site Specific Management: A Remote Sensing Approach
Prakash Basnyat, Brian McConkey, Guy Lafond,
Yann Pelcat, Alan Moulin..... 1

Indian Head Precision Farming Research Project, Variable Rate Application of N to Wheat.
Alan Moulin, AAFC Brandon, MB..... 15

Background Deep Nitrate Leaching at IHARF Precision Farming Center.
Brian McConkey, AAFC, Swift Current, ... 33

EM38 Study of IHARF Precision Farm.
Garth Weiterman, Sask Water, Agro Environmental Unit, Outlook, SK.....35

Indian Head Precision Farming Project, Summary of 2001 Crop Yield.
Yann Pelcat, IHARF Precision Farm Manager, Indian Head, SK
Guy Lafond, Indian Head Research Farm..... 40

Weed Research, Indian Head Precision Agriculture Project. Summary of Activities 2001.
Yann Pelcat, IHARF Precision Farm Manager, Indian Head, SK
Guy Lafond, Indian Head Research Farm..... 44

Profitability Evaluation of the IHARF Precision Farm Since 1998.
Yann Pelcat, IHARF Precision Farm Manager, Indian Head, SK
Guy Lafond, Indian Head Research Farm..... 50

Indian Head Precision Farm Activities 2001, Disease Rating for All Fields.
Bruce Gossen, Ken Bassendowski, AAFC Saskatoon, SK..... 98

Site Specific Management: A remote sensing approach...

Guy P. Lafond[1], Prakash Basnyat[2], Yann Pelcat[3], Brian McConkey[2] and Alan Moulin[4]
[1] Indian Head Research Farm, Box 760, Indian Head, SK, S0G 2K0
[2] Swift Current Research Centre, P.O. Box 1030, Swift Current, SK, S9H 3X2
[3] Indian Head Agricultural Research Foundation, Box 156, Indian Head, SK, S0G2K0
[4] Brandon Research Center, P.O. Box 1000A, R.R.#3, Brandon, MB, R7A 5Y3

ABSTRACT

The Indian Head Agricultural Research Foundation, a not-for-profit producer organization in Indian Head, SK, purchased 308 acres in 1997 to dedicate to Precision Farming research. Their interest was in developing protocols for delineating management zones within a field. The objective of the study was to find cost effective ways of assigning management units to a field without having to resort to a one-acre grid soil sampling and analysis approach which is very costly and time consuming.

The 308 acre field was divided into eight-38.5 acre parcels. A spring wheat - canola - spring wheat - field pea rotation was established such that each phase of the rotation was present twice resulting in a two replicate study. The size of the parcels allowed for the use of a commercial combine equipped with a yield monitor and GPS unit. It also allowed for the study of remote sensing imagery. A one-acre grid sampling scheme was superimposed on each field. A steel geo-referenced pin was inserted in the soil at each grid point for easy identification of the grids points. In 1998 and 1999, each field was treated uniformly in terms of fertilizer, seed and herbicide application to allow for the collection of baseline information. A variable rate nitrogen prescription map was superimposed on each spring wheat and canola field in 2000 and 2001 based on the nitrogen removal information from crops and soil test N levels or normalized difference vegetation index (NDVI) information from satellite remote sensing data from different sources (SPOT or Landsat TM or IKONOS). In this poster we are looking at the use of NDVI to delineate management zones.

Results of this study show that the correlation between NDVI and grain yield varies temporally as well as with crop types and source of data. Correlation between wheat yield and NDVI (extracted using satellite data from year 2000) varies between 0.05 to 0.8 whereas Canola yield and NDVI varies between 0.21 to 0.61 showing the usefulness of NDVI to be used as proxy of crop productivity.

Based on these relationships, management zones were delineated using NDVI extracted from 1998 and 1999 Landsat imagery using FUZME software. Optimal number of management zones were selected based on the variance reduction criteria using grain yield information. The result of this analysis identified four zones indicating variability in the crop vigor. The mean normalized yield in each of these zones were calculated as 0.29, 0.46, 0.48 and 0.66 respectively matching the conclusion of NDVI. The advantage of using information from secondary sources

like satellite imagery are costs and availability of historical archived information of the area of ones's interest as well as straight forward procedure to extract and use these information for site-specific management.

INTRODUCTION

The interest in site-specific management is a function of the possibility of applying crop inputs more efficiently with the desired end-result of increasing net returns. The greatest difficulty encountered with the concept of site-specific management is deciding which field measurements should be done and whether or not the variability measured has a strong relationship to final grain yield. Examples of measurements used in the past are grid soil sampling for macro-nutrients, soil electrical conductivity and digital elevation models. The obvious one is yield maps obtained from a combine equipped with a yield monitor and global positioning system. In order to obtain yield maps, you need to have access to the proper equipment which is not the case for many producers. There is also a lot of error associated with yield maps because of the positioning system and to a lesser extent the actual weighing system on the combine. The problem with all these measurements is the labour and costs associated in collecting the data.

In order to circumvent this problem, we have examined the merits of using remote sensing images as an indirect way of estimating grain yield based on measurements of biomass. The biomass estimation is based on the measure of normalized difference vegetative index (NDVI) which is a measure of the ratio of different wavelengths in the near-infra red and infra-red range ie. (NIR-IR)/(NIR+IR). The advantage with this approach is that the images are readily available and for a large number of years, depending on which satellite you are dealing with and the resolution at the field level ie. 30 m or less. The disadvantage is that some training in GIS and remote sensing is required in order to develop these maps which requires specialized software. However, companies do exist to deliver this type of product in a very cost effective way.

The objective of this study was to examine the feasibility of using NDVI measurements determined from satellite imagery and the clustering procedure of "Fuzzy K Means" (deGruijter and McBratney, 1988) for delineating management zones within a field and to correlate these zones to final grain yield obtained from a combine yield monitor and positioning system

MATERIALS AND METHODS

Field Study

In order to validate this approach, the Centre for Precision Farming at Indian Head was used as the test site (IHARF, 1999). The test site consists of a 308 acre field divided into eight fields of 38 acres (Figure 1). The area was seeded with the seeder attached with GPS guidance system (Figure 2). A spring wheat - field pea - spring wheat - canola rotation was superimposed such that each phase of the rotation is replicated twice. The fields were large enough so that it

combine equipped with a yield monitor and GPS unit(Figure 3) . At the start of the study in 1998, a one-acre grid was established over the entire study area. Each grid point was geo-referenced and a steel pin inserted into the ground for a permanent reference point. All subsequent field measurements taken were referenced to these pins. All crops were direct seeded into standing stubble and appropriate agronomic practises used for each crop. For more information about the study, please consult the website: http://paridss.usask.ca/precisionfarm

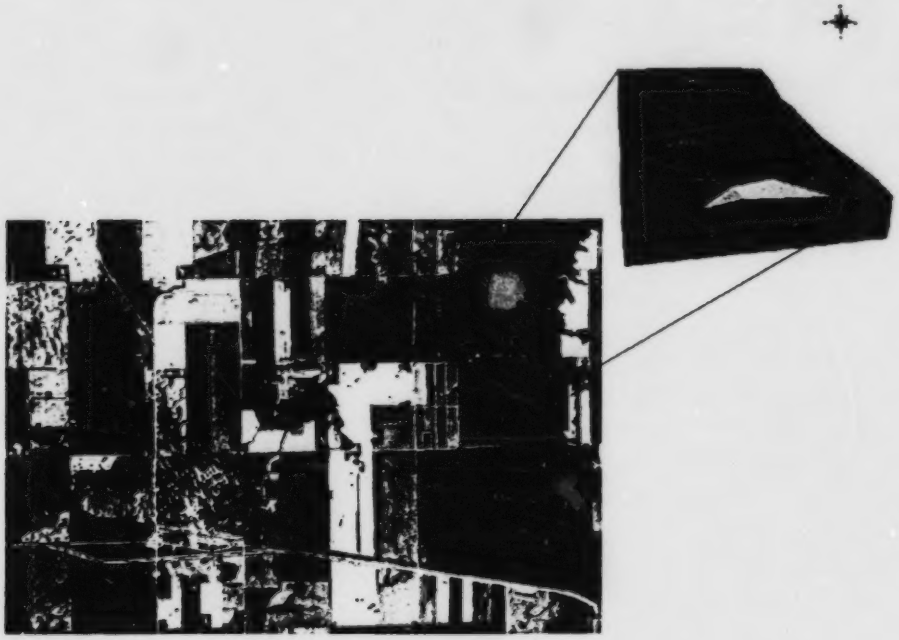


Figure 1. Aerial View of Site

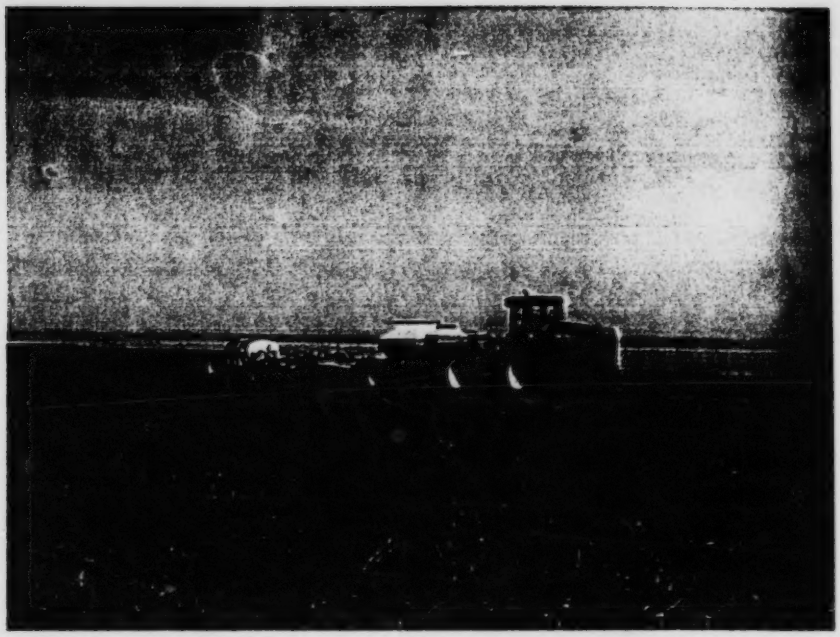


Figure 2. No-Till Seeder Equipped with Variable Nitrogen Rate Capabilities.

Figure 3. Combine with Yield Monitor and Global Positioning System.

Data Analysis

Successful site-specific management requires knowledge about the in-field variability of soil properties and the response of crops to those properties. This can be achieve through intensive soil sampling and surveying. However, intensive sampling is costly and there is no guarantee that the information you are collecting is highly related to overall grain yield or can account for a significant proportion of the yield variability. In this situation, by using NDVI which is a measure of crop vigor, represents a variable that has a direct impact on crop productivity. The information, based on remote sensing imagery, is very easy to obtain, is relatively low cost and it is easy to extract the information.

As part of this overall project, remote sensing information was obtained from different sources i.e. Landsat TM (30 meter spatial resolution), SPOT (20 meter spatial resolution), and IKONOS (4 meter spatial resolution). Since red band (630 - 690 nm) near-infrared band (760 - 900 nm) are considered the most useful for calculating NDVI which is a measure of biomass accumulation (Lillesand Kiefer 1994). The NDVI is calculated from two channels using the relationship identified in equation #1.

$$NDVI = \frac{ValueofInfraredBand - Valueof\ RedBand}{ValueofInfraredBand + Valueof\ RedBand} \qquad (1)$$

The #1 equation produces NDVI values in the ranges of -1.0 to 1.0, where negative values generally represent clouds, water, and other non-vegetated surfaces, and positive values represent vegetated surfaces. The NDVI relates to photosynthetic activity of living plants. The higher the NDVI value, the more "green" the cover type. It means that the NDVI increases as the quantity of green biomass increases in an area. Once, the NDVI information from each of these sources were extracted. NDVI from these different sources were compared and correlated with N uptake after normalizing in order to remove difference in scale among the variables (Stevenson et al, 2001). The normalization were preformed as indicated in equation #2:

$$X_i = \frac{x_i - (\bar{x} - 2S.D.)}{4S.D.} \qquad (2)$$

Where:
X_i = The transformed value.
x_i = The observation i.
$\bar{x}$ = The mean of the observations.
S.D. = Standard Deviation

Grain Yield

Grain yield measurements were obtained using combine yield monitor. Yield information of wheat were extracted from the yield information of 1998 (field number 1, 3, 6, and 8) and 1999(field number 2,4,5, and 7). After normalizing, using Equation (2), both data sets were combined and a grid surface was generated using a krieging process (Isaaks and Srivastava 1989). The grid surface generated reveals the grain yield pattern of the spring wheat in the study area, which shows variation within and between experimental plots.

Clustering Process

In order to delineate management zones using NDVI information, imagery from the Landsat TM satellite for the years 1998 and 1999 was used to match the collected information on yields of spring wheat. The identification and delineation of management zones was done using an unsupervised classification or clustering method which helps in identifying naturally occurring clusters of data. The clustering algorithm used was the fuzzy k-means with extra-grades (deGruijter & McBratney 1988) which is a modification of fuzzy c-means (Bezdek, 1981). This modified algorithm is based on the assumption that continuous classes provide better representations of outliers or atypical individuals than discontinuous classes. This is especially the case with outliers located between clusters (i.e., intra-grades). Fuzzy k-means, for instance, will give intermediate memberships to intra-grades. However, outliers outside the main body of data points, referred to as extra-grades, are still not suitably represented by fuzzy k-means. deGruijter & McBratney (1988) modified the objective function to account for extra-grades. This improvement makes the memberships directly depend upon the distances to the class centroids. The classification was accomplished using the program "FUZME". developed at the Australian Centre for Precision Agriculture (Minasny and McBratney 2000). This software determines membership in each cluster through an iterative process beginning with a random set of cluster means. Each observation is assigned to the closest to these means. New means are recalculated for each cluster based on the distance (Euclidean, Diagonal, or Mahalanobis) from the observation to cluster mean. To ensure cluster stability, the process is repeated until either the specified convergence criterion is met or the maximum number of iterations, stopping criterion, fuzziness exponent, and distance metric is met. The software generates a data file containing each observation, the cluster to which it belongs, and a vector of membership values to indicate how closely each individual resembles each cluster. To obtain good convergence, a stopping criterion of 0.00001 was used in this study, which means the change in membership with an iteration of means calculation was less than 0.00001. Because, the variables used for classification exhibited significantly different ranges, the distance metric was set as to Mahalanobis. In this mode, the data set is transferred to one in which all attributes have zero mean and unit variance. Correlations between variables are accounted for as well (McBratney and Moore, 1985). The optimum number of zones were decided based on the fuzziness performance index (FPI) and modified partition entropy (MPE). FPI estimates the degree of fuzziness generated by a specified number of classes. MPE estimates the degree of disorganization created by a specified number of classes. Hence, both of these measures serve as a first step in determining optimum number of classes on

the basis of minimizing these two measures (Roubens 1982).

Performance Analysis

Spring wheat yield information for 1998 and 1999 was used to analyze the performance of the optimal number of zones identified by the FUZME.

$$S_z^2 = \frac{1}{n_z} \sum_{i=1}^{n_z} (Y_I - \bar{Y}_Z)^2 * \frac{n_z}{n_T}$$

For better comparison, weighted yield variances for each zone based on the area of the zone (Fraisse and others 1999) as described below were used. The weighted variance was calculated using equation #3:

(3)

Where:
S_z^2 = Weighted variance for zone Z;
Y_i = Normalized grain measured for cell i;
$\bar{Y}_z$ = Mean of the normalized measured grain yield in the zone Z;
n_z = Number of cells in zone Z;
n_T = Total number of cells in the map.

The decrease in total within-zone variance was used as a decision criterion in selecting better information source. Total within-zone grain yield variance of a map was defined as the sum of weighted within-zone yield variances for each zone as indicated in equation #4:

$$S_T^2 = S_1^2 + S_2^2 + \ldots\ldots + S_z^2 \qquad (4)$$

RESULTS AND DISCUSSION

The correlations between grain yield and NDVI from different sources are presented in Table 1. NDVI from SPOT imagery taken at different times during the growing season shows the changes in the magnitude of the correlation with stage of crop growth. The relationship between NDVI extracted using Landsat TM data and crop yield shows a statistically significant correlation

as well. Based on the availability of archived data, spectral resolution, cost of imagery and ease of information extraction, Landsat TM was chosen as the data source. Though IKONOS data from a newly launched satellite has improved resolution (4 m vs 30 m), the major disadvantage is that the images always have to be pre-ordered, are more expensive and there is no way of accessing archived information. Accessing imagery from the SPOT satellite is also possible because archived information can be accessed, but the number of spectral bands are limited and it is more costly than Landsat TM.

Table 1. Pearson Correlation Matrix.

Field Number	Crop	SPOT June 29	SPOT July 26	SPOT Aug 15	TM July 26	IKONOS Aug 27
1	Wheat	*0.05**	*0.35*	*0.47*	*0.4*	*0.65*
2	Canola	*0.61*	*0.59*	*0.4*	*0.36*	*0.4*
3	Wheat	*0.74*	*0.88*	*0.73*	*0.77*	*0.74*
4	Peas	*0.8*	*0.92*	*0.04*	*0.89*	*0.21**
5	Peas	*0.53*	*0.68*	*0.27**	*0.49*	*0.1**
6	Wheat	*0.35*	*0.78*	*0.83*	*0.63*	*0.83*
7	Canola	*0.39*	*0.55*	*0.54*	*0.42*	*0.21**
8	Wheat	*-0.07**	*0.7*	*0.76*	*0.51*	*0.72*

* N.S. at 95%

Grain Yield

Grain yield measurements were obtained using a combine yield monitor . Yield information for wheat were extracted from data obtained in 1998 (field number 1, and 6) and 1999(field number 2,4,5, and 7). After normalizing, using Equation (2), both data sets were combined and a grid surface was generated using a Kriging process (Isaaks and Srivastava 1989). The grid surface generated reveals the grain yield pattern of the spring wheat in the study area, which shows variation within and between experimental plots (Figure 4).

Normalization resulted in the transformed grain yield information with mean 0.5 and standard deviation 0.25. With the normalization we were able to combine the both year information by removing the effect of unintended variation. After combining data these normalized yield information were used in creating grid surface using Kriging interpolation method. The results clearly shows the variation in the grain yield within each plot as well as between plots (Figure 4).

Figure 4. Normalized Grain Yield Based on 1998 and 1999 Spring Wheat Yield Information

Delineation of of Management Zones

The unsupervised classification procedure was used to delineate management zones. In this process, "Fuzme2" software was used for the clustering portion of the study area behaving similarly and separating with dis-similar area. Explanatory variable vegetation index was used in this process with the assumption of it being a proxy for overall crop productivity. The software uses the fuzzy k-means algorithm for clustering. The algorithm requires users to define the minimum and maximum number of management zones to be delineated. In our case we defined 2

as a minimum and 16 as a maximum number of management zones. Based on user-defined criteria, the software assigns each points to a group. After classification, optimum number of management zones were determined based on the FPI and MPE index. The FPI is a measure of the degree to which different classes share membership and is constrained to values between 0 and 1. As FPI approaches 1, membership sharing increases. As the FPI approaches 0, classes become more distinct with less membership sharing. The MPE is an estimate of the amount of disorganization created by a specified number of classes. Like the FPI, it is also constrained to value between 0 and 1. As MPE approaches 1, disorganization predominates while values approaching 0 indicate excellent organization. Plotting the values of FPI and MPE against the number of classes and choosing a classification that minimizes both measures was the criteria used in the identification of the optimum number of zones (Figure 5).

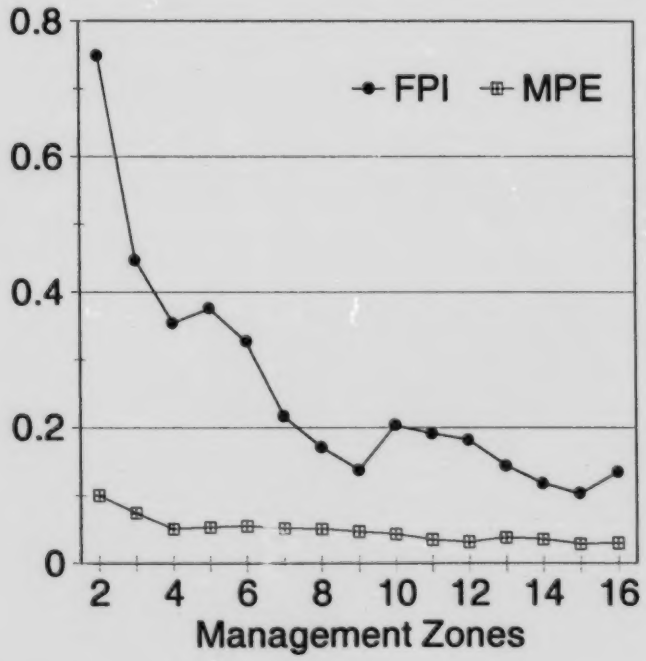


Figure 5. Plots of Clustering Performance Against the Number of Management Zones.

From the Figure 5, we observe that the decrease in FPI and MPE reaches maximum when it reaches 4 management zones, then the values start to decrease slowly. Hence, in our analysis we start comparing with four zones and end with eight zones for each option. Performance of each options were evaluated using the grain yield information which was also used to validate the zone identified by the FPI and MPE.

Performance Analysis

Based on the clustering performance shown in the Figure 5, we have chosen four management zones as the optimal number of zones. This selection of optimal number of management zones was based on the clustering performance and practicality in delineating and working within these zones. It can be seen from the Figure 5 that as the number of zones increase, both the performance index decreases and reaches zero when we delineate as many management zones as there are within-field variability. In essence, we will be able to get minimum variability if we treat every plant differently, which is practically and economically not possible. It may be feasible in for certain high value crops i.e.. premium win producing grape orchards. Hence, we have to balance the cost of having a large number of management zones and the net benefit generated from working with a large number of management zones.

Fisher's Least-Significant-Difference Test was conducted to compare grain yield means from each zone. The results of this analysis showed that the mean yield inside each of the four zones were significantly different. Considering total variance of standardized grain yield without zone segmentation as 100 percent, total variance calculated for the four management zones delineated using Landsat TM information was 87 percent (Figure 6). This shows a reduction in the variance by 13 percent.

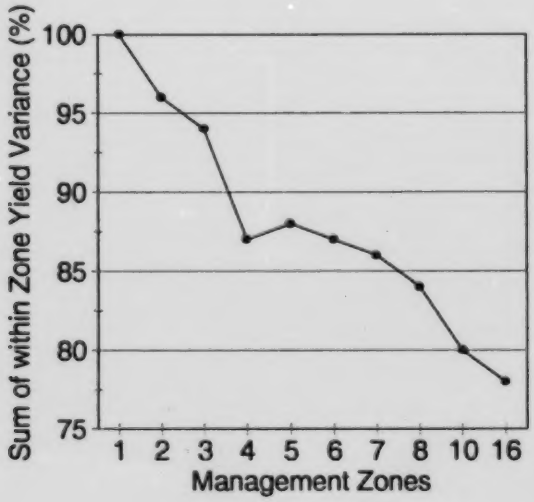


Figure 6. Optimal Management Zone Verification

Landsat TM imagery with a resolution of 30 meters is useful in providing information which can be used in the delineation of management zones (Figure 7). The advantage of using Landsat TM are it's availability and low cost . Another advantage of Landsat TM is availability of

historical information from their archives, which may address the issue of the time required to collect sufficient information on a field before we can apply a proper management program to derive the full benefits of the field in question. With the recent introduction of Landsat TM 7, information will no longer be copyrighted which will allow producers to share information from a given scene. There also exists several agencies that can provide imagery at a cost of $0.12 per acre. Some additional costs will be incurred to process the data into usefull products that can be accessed by variable rate application software.

Figure 7. Optimal Number of Management Zones for the Center for Precision Farming at Indian Head.

CONCLUSIONS

The results of this study support the hypothesis that it is possible to develop management zones that relate directly to field productivity, in this case grain yield, based on NDVI derived from remote sensing data. Once the zones have been developed, the producer can then choose to vary inputs according to those zones. The producer will have to decide which input needs to be changed within each zones. This approach also allows the producer to observe carefully why the zones are producing differently and come up with reasons for these differences. Each field will be

unique and as such a different approach will likely be required to capitalize on the unique potential of each field. This approach, because of the availability of past and present remote sensing images, would also allow a producer an assessment of the relative productivity of a neighbouring field that he may be contemplating buying.

REFERENCE

Bezdek, J.C., 1981. Pattern Recognition with Fuzzy Objective Function Algorithms. Plenum Press, New York.

deGruijter, J.J., McBratney, A.B., 1988. A modified fuzzy k means for predictive classification. In: Bock,H.H.(ed) Classification and Related Methods of Data Analysis. pp. 97-104. Elsevier Science, Amsterdam.

Fraisse, C.W., K.A. Sudduth, N.R. Kitchen, and J.J. Fridgen 1999. Use of unsupervised clustering algorithms for delineating within-field management zones. Paper No. 993043, ASAE, Toronto, Ontario, Canada.

Indian Head Agricultural Research Foundation (IHARF). 1999. Website: http://paridss.usask.ca.

Issaks, E.D., and R.M. Srivastava 1989. An Introduction to Applied Geostatistics. Oxford University Press. New York. 561p.

Lillesand , T.M., and R.W. Kiefer. 1994. Remote sensing and image interpretation (third edition). John Wiley and Sons, Inc., New York, 750 p.

McBratney, A.B., Moore, A.W., 1985. Application of fuzzy sets to climatic classification. Agricultural and Forest Meteorology 35, 165-185.

Minasny, B., McBratney, A.B., 2000. FUZME version 2.1, Australian Centre for Precision Agriculture, The University of Sydney, NSW.(http://www.usyd.edu.au/su/agric/acpa).

Roubens, M., 1982. Fuzzy clustering algorithms and their cluster validity. European Journal of Operational Research 10, 294-301.

Stevenson, F.C., J.D. Knight, O. Wendroth, C.van Kessel, and D.R. Nielsen 2001. A comparison of two methods to predict the landscape-scale variation of crop yield. Soil and Tillage Research. 58:163-181.

ACKNOWLEDGEMENT

This project was made possible with funding received from Agriculture and Agri-Food Canada, AAFC's Matching Investment Initiative, Canada-Saskatchewan Agri-Food Innovation Fund, Canadian Adaptatation and Rural Development Saskatchewan, Saskatchewan Agriculture and Food, Royal Bank of Canada and the Indian Head Agricultural Research. New Holland North America, Flexi-Coil, Markusson New Holland, Pattison Liquid Systems Inc, Wilger Industries Ltd., MacDon Industries, Simplot Agribusiness, Aventis Crop Science (now Bayer), Monsanto, WESTCO Fertilizers, BASF, MidWest Techologies, OmniStar, Dow AgroSciences, Network Innovation, Lonesomeview Farms, Zenecca (now Syngenta) and Brandt Industries provided in-kind sponsorship through equipment and crop inputs.

Indian Head Precision Farming Research Project, Variable Rate Application of N to Wheat

A. Moulin[1]

March 5, 2000

[1]AAFC, Brandon, MB, R7A 5Y3

Introduction

This is an interim report on research conducted in 2000 and 2001 at the Indian Head Agricultural Research Farm, funded by the Agri-Food Innovation Fund (AFIF), Indian Head Agricultural Research Foundation and the Matching Industry Initiative Fund of Agriculture & Agri-Food Canada. The report summarizes activities, significant findings of the research and describes proposed plans for the 2001 field season.

Objective

The overall objective of the treatment structure in 2000 and 2001 was to evaluate variable rate N application based on crop yield, N removal and soil test nitrate-N.

Background

Variable-rate fertiliser management systems can improve efficiency of fertilizer use and environmental sustainability. Adoption of this technology has been hampered due to the difficulty of classifying fields into management units, the high cost of sampling soils on a grid basis, and the variability of soil and plant properties in the landscape. Technology for variable rate fertilizer systems is available, but there is little information available related to yield response for agronomic studies, and the relationship of plant tissue test levels in relation to soil fertility as measured by soil test nitrate nitrogen.

Current soil test recommendations for nitrogen are based on soil test nitrate nitrogen from samples bulked from samples in several locations in the field preferably grouped according to topography. Variability of nitrate nitrogen can vary considerably in landscapes, Cahn et al. (1994) determined the spatial pattern of nitrate nitrogen changed with time, and the frequency distribution was skewed due to a few outlying values, which greatly exceeded the mean. Solohub et al. (1999) concluded mineral nitrogen is highly variable both across the landscape and over distances less than one meter. Current research on variable-rate fertilizer management has focused on potential crop yield in relation to factors such as erosion and soil fertility as it varies from upper to lower slope positions.

Variability of crop production has been related to the thickness of topsoil (Gregorich and Anderson 1985, Pennock and De Jong 1990) and soil moisture (Verity

and Anderson 1990). Previous research (Moulin et al 1994) showed crop yield and soil erosion were related to a multivariate factor composed of relative elevation and surface curvature. Variability of crop yield in a glacial-till landscape was attributed to the effect of relative elevation and surface curvature on overland flow of water and related soil properties.

Subsequent research (Beckie et al 1997) evaluated variable rate fertilizer management in a field classified according to slope position, organic matter and residual soil test nitrogen. The highest efficiency of fertilizer use was found when nitrogen fertilizer was variably applied to land classified according to topography.

Given the considerable variability of crop yield and soil nitrogen, and the significant costs of grid sampling and chemical analysis, the potential for precision agriculture in the Prairie region based on these technologies is prohibitive. Results of this research indicate the variability of soil nitrogen and other properties, is high and not necessarily directly related to elevation or topography in glacial till. Solohub et al. (1999) also found significant variability in mineral nitrogen over short distances in glacial till soils, and suggested bulking a number of samples from a small area to improve resolution. The large number of samples in this study provides considerable statistical power to the analysis of the relationships with elevation and other variables, but this level of sampling is uneconomic in a crop production system.

Two management systems have been proposed to deal with the need to adequately and economically quantify spatial variability of soil properties and implement variable rate fertilizer. The first is termed "zone management or patch management" and is based on dividing fields into zones based on yield, surface reflectance based on air borne or satellite imagery, and digital elevation maps (Viscarra Rossel and McBratney 1998). Soils and plants are then sampled within these zones. This system reduces the number of samples, analyses and costs related to variable management. Zone management would allow producers to avoid sampling soils, which unduly influence the calculation of means and result in an underestimate of fertilizer requirements. Results of this study indicate the high spatial and statistical variability may preclude zone or patch management.

Although zone management has proven effective in moisture limited soils (Beckie et al 1997) data from studies at Brandon (Cynthia Grant personal communication) and at the Manitoba Zero Tillage Research Farm (Moulin unpublished data, 1997-2000) show patterns of crop yield in the landscape vary considerably with growing season precipitation. For example, crop yield in lower slope positions may be high in dry years but low in wet years.

The second management system is based on intensive sensing or scanning. Real-time sensors of soil or plant properties show considerable merit for implementation of precision agriculture (Viscarra Rossel and McBratney 1998). These sensors, which would collect information and control application of fertilizer at the same time, would be mounted on seeders for solid fertilizers, or sprayers for nitrogen solution. The high costs of labour, time and management of soil information would be reduced through this

system. This management system is based on the assumption the technology would be cost effective and apply fertilizer in response to variability of plant nutrient requirements.

Potential scenarios for variable rate N management at the IHARF project

Two potential scenarios for variable rate N management were identified. The first scenario is based on a combination of yield and protein monitors with soil test nitrate-N. The second is based on use of spectral reflection for application of in crop nitrogen. The first scenario was chosen for evaluation in the field season of 2000 after evaluation of yield and N content of crop data for 1999.

Yield and protein monitors

Maps of crop nitrogen uptake, derived from yield and protein monitors, are now technically feasible (Engels et al 1999). This will permit calculation of nitrogen removal from the field, permitting application of nitrogen on a variable basis to areas of greatest use. The combination of nitrogen removal by crop and soil test nitrate-N for fields would provide a simple calculation of fertilizer application. Nitrogen application would be applied in the areas of highest N removal and crop yield thereby increasing efficiency.

Reflectance meters

The application of spectral reflection to real-time application of nitrogen is a potential technology for variable application of N. This technology is based on the assumption that canola, wheat or other crops will respond to an in-crop application of nitrogen solution. Canola yield was significantly related to higher crop biomass, which in turn was correlated with reflection at 760 and 810 nm in related research at Brandon Manitoba. This relationship was not significant in 1999 at Indian Head due to the presence of uniformly high crop biomass. Nonetheless reflectance data should be continue to be collected as in-crop application of N based on reflectance would theoretically be the most efficient of these two scenarios. It would include information for increased potential production as reflected by factors such as plant response to seasonal variability in growing season precipitation. The Hydro N-sensor developed by Hydro Agri GmbH Deutschland uses spectral reflectance to variably apply nitrogen fertilizer in corn. The same technology could be applied to small grains and oil seed crops in Western Canada given sufficient calibration.

Methods

Fertilizer rates 2000

In spring 2000 variable and fixed nitrogen rates were calculated for fields (Figure 1) to be seeded to wheat. Soil NO_3-N sampled to 60 cm in a one-acre grid survey (308 sites) was used in conjunction with crop yield and N removal in crop.

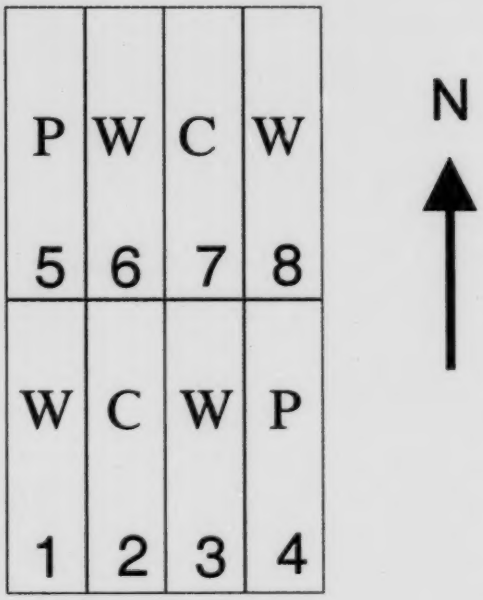


Figure 1. Crop blocks for 2000. w-wheat, c-canola, p-peas

Fertilizer Rates 2000

N Fertilizer rates were calculated based on 4 different scenarios in Farm Phase 2 (Envirotest Labs):

23 bushel/acre yield goal for 5.1 inches rain

46 bushel/acre yield goal for 10.6 inches rain

50 bushel/acre yield goal

50 bushel/acre yield goal, variable rate N

Variable N Rate Calculation 2000

Variable nitrogen rates were calculated by setting the initial fertilizer N recommendation to a yield goal of 50 bushels based on average soil test for the field and adjusted for preceding canola or peas

N fertilizer was reduced in lower yielding parts of the field by multiplying by a factor equal to:

N in crop removed/maximum N removal for the field

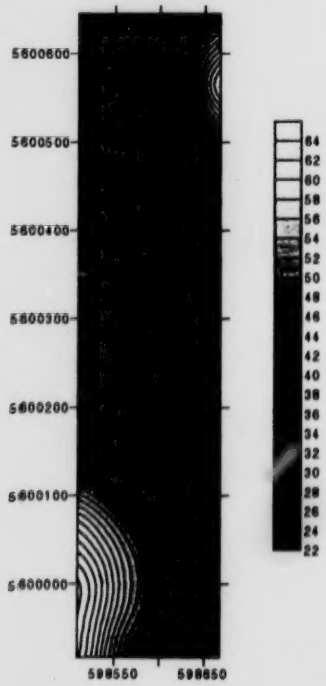


Figure 1: Soil test nitrate, field 1 1999

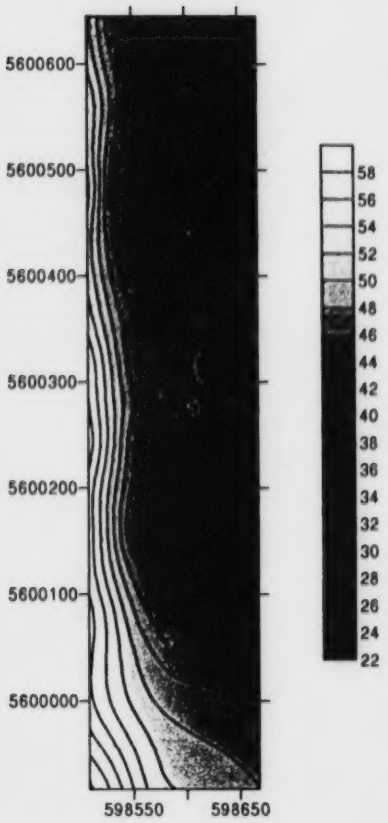


Figure 2. Canola Yield, field 1 1999 (bus/ac)

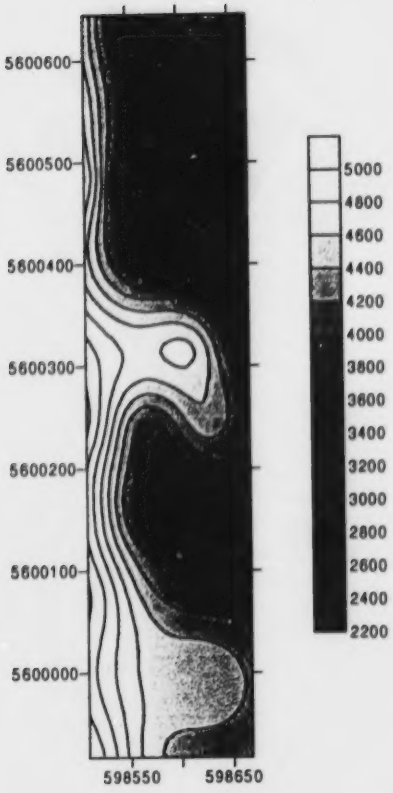


Figure 3. N removal, field 1 (kg/ha)

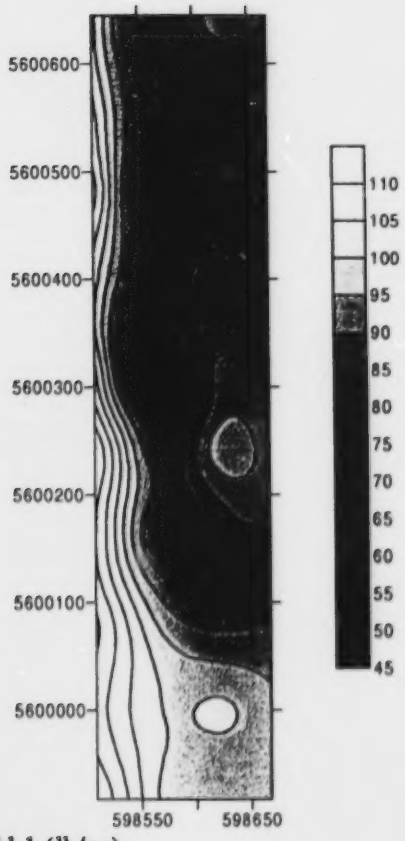


Figure 4. Variable Rate N fertilizer, field 1 (lb/ac)

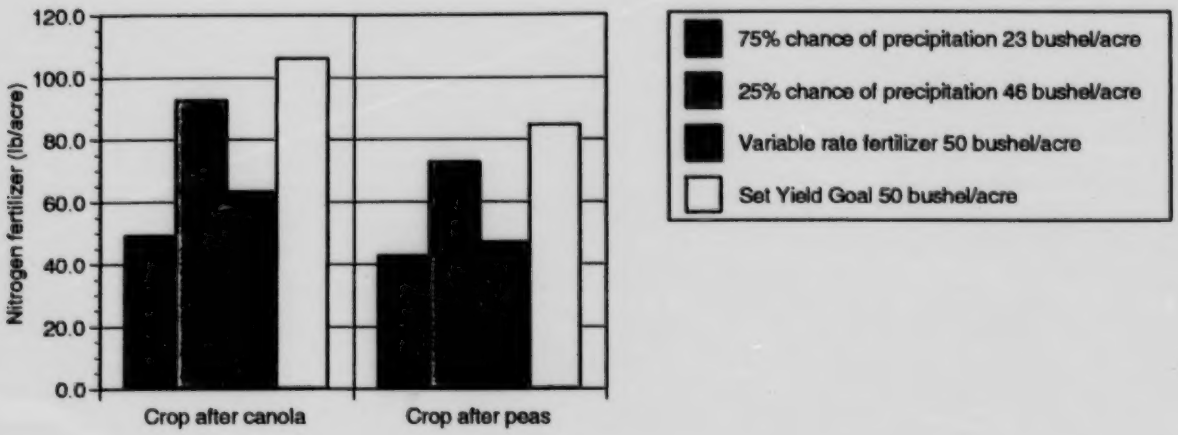


Figure 5. Average fertilizer N in two fields applied for wheat (lb/acre)

Table 1. Fertilizer applied lb N/ac

Fertilizer rates lbN/ac

	Yield Goals			
Field	23 bus/ac fixed	46 bus/ac fixed	50 bus/ac fixed	50 bus/ac variable
1	47.1	103.9	118.9	103.4
3	32.1	62.1	73.9	22.3
6	51.1	81.0	92.8	23.0

Fertilizer rates 2001

In spring 2001 fixed nitrogen rates were assigned to the fields (Figure 6). Nitrogen fertilizer rates of 55, 75, 90, 105, 120, 135, and 150 kg ha^{-1} were established.

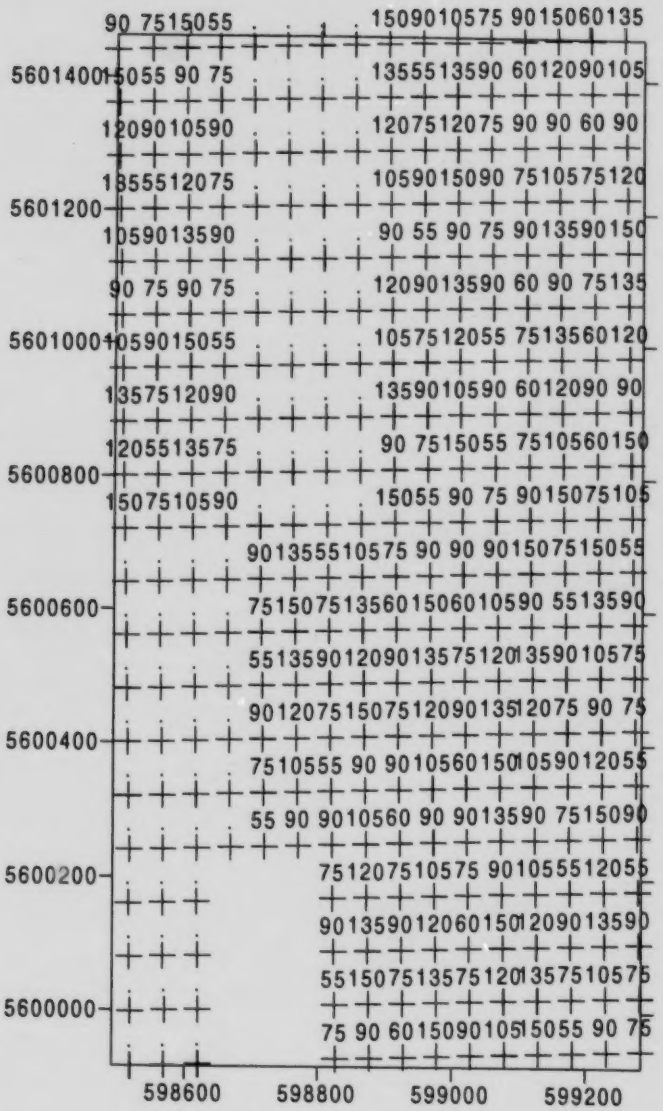


Figure 6. Fertilizer rates N for wheat and canola (kg ha^{-1}). Axes are easting and northing in metres.

Results 2000

Wheat yield was significantly different (P=0.0826) due to N fertilizer treatment. Yields were significantly higher in wheat fertilized with a yield goal of 50 bushels/acre compared to 23 bushels/acre (P=0.0354). They were significantly higher in wheat fertilized with a yield goal of 46 bushes/acre compared to 23 bushels/acre (P=0.088).

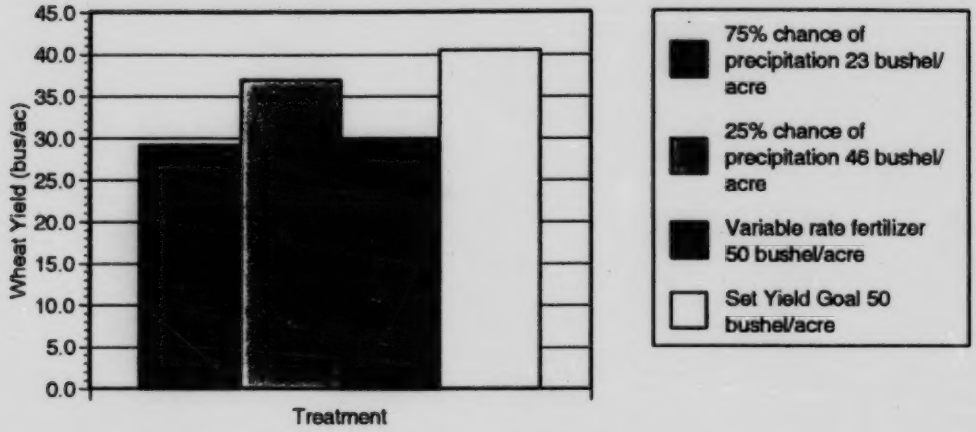


Figure 7. Wheat Yield in response to N fertilizer 2000.

No significant difference was observed in wheat yield following canola or peas Nitrogen fertilizer rates following canola were increased to compensate for the benefit of peas preceding wheat. Wheat yield was low in variable rate fertilizer treatments relative to 50 and 46 bushel/acre goals. Nitrogen inputs were not located in the proper field locations in the variable N rate treatments, due to an error in transcription of fertilizer rates between spreadsheets.

Growing season precipitation in 2000 exceeded those levels used in the calculation of the yield goals and N application rates. This points out the difficulty of developing variable rate application for soils where soil moisture may or may not be a limiting factor. However, there was a significant increase in production with increasing application of N fertilizer (Figure 7).

Yield Trends in Field 1

There is a significant increase in yield in the southwest corner of field 1, which appears to be correlated with increased soil carbon. This trend is not evident in other parts of the field and further investigation is required. Management appears to have varied between 1958 and 1966, which may have influenced yield patterns.

Figure 8. Air photo 1946

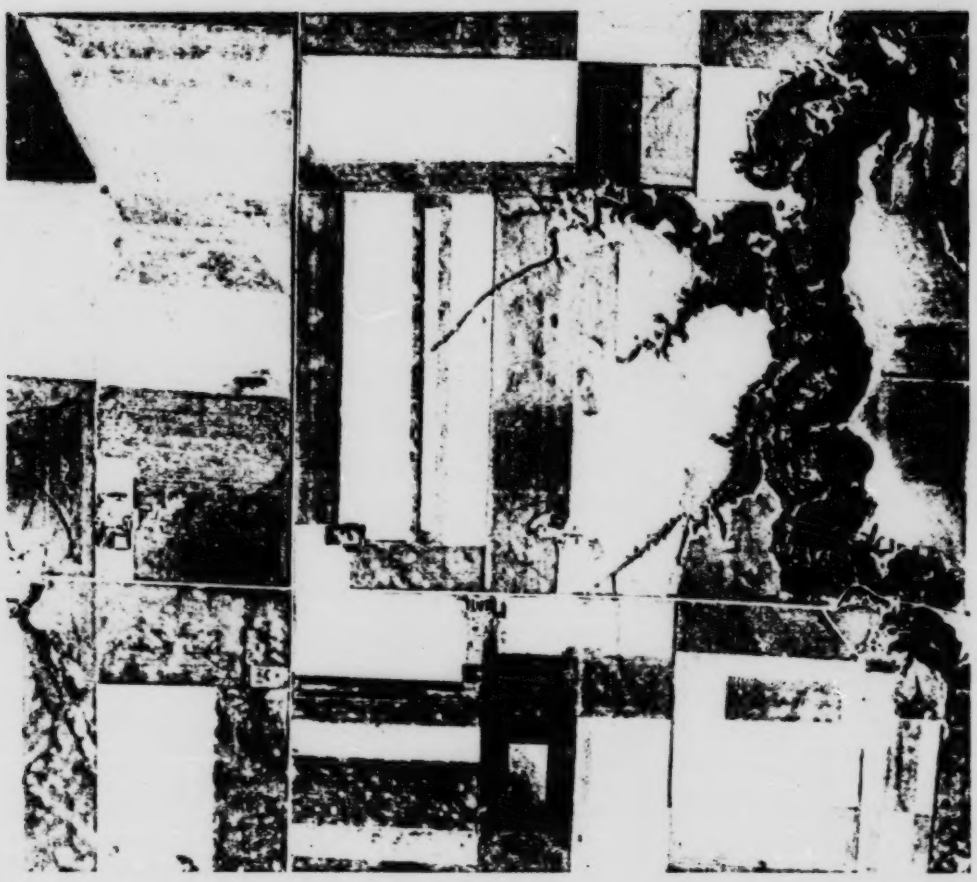


Figure 9. Air Photo 1958

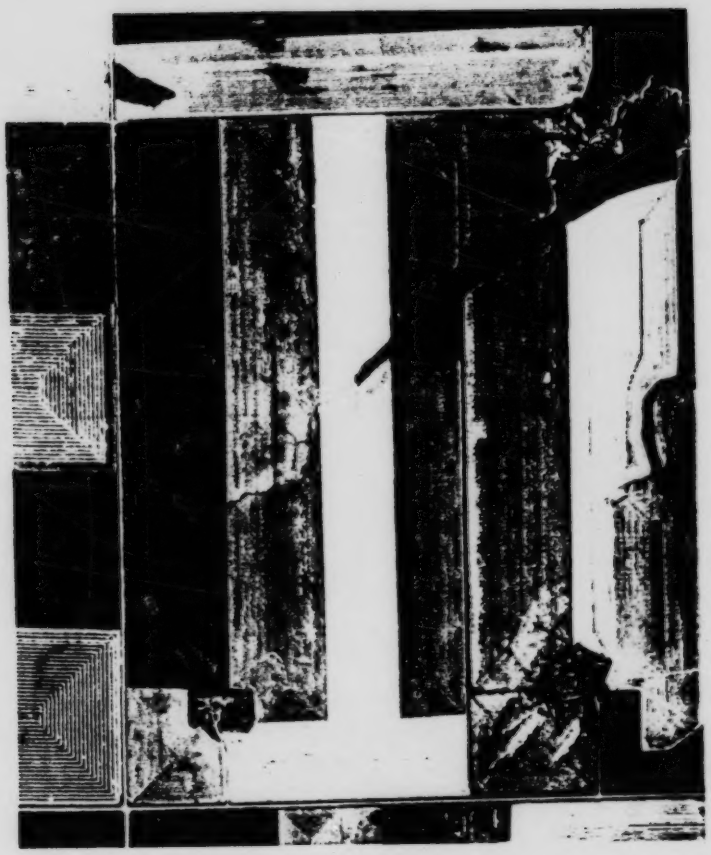


Figure 10. Air Photo 1965

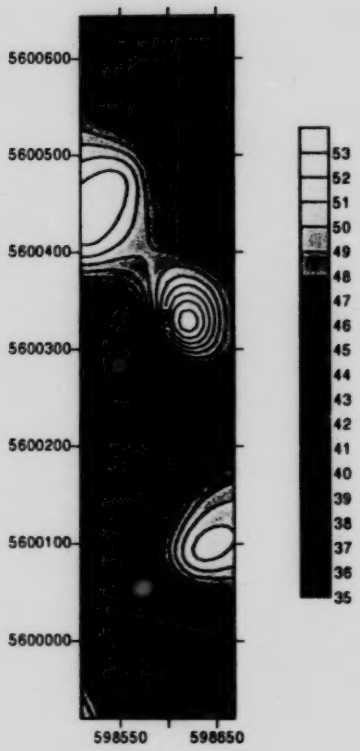


Figure 11. Soil organic carbon 0-6 inches in field 1 (Metric Tonnes/Hectare)

Soil Properties

Soil nitrate-N and sulphate-N, measured in fall 2000 were significantly correlated with those for fall 1999. This indicates soil test data were consistent between the two years. Crop yield in 2000 averaged over all crops was not significantly correlated with fall 2000 soil test data, though protein content of spring wheat was significantly correlated with soil nitrate nitrogen. Spring wheat production was correlated with Protein content and soil nitrate nitrogen were not significantly correlated in 1999.

Results 2001

Wheat yield was significantly different (P=0.0704), increasing to 105 kg ha^{-1} of nitrogen fertilizer then decreased to 150 kg ha^{-1} (Figure 12). Wheat protein also increased from 15.25% to 16.25% for fertilizer rates of 55 and 90 kg ha^{-1} respectively, with no significant increase at higher rates (Figure 13).

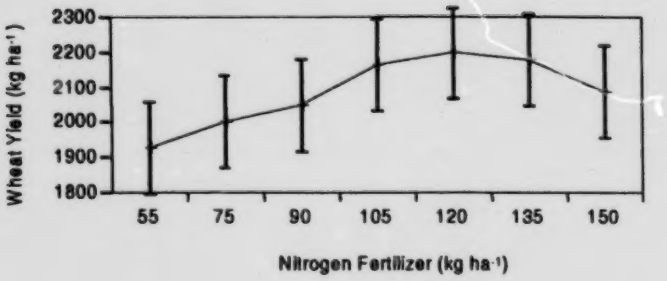


Figure 12. Wheat yield (kg ha^{-1}) as influenced by nitrogen fertilizer (kg ha^{-1}). Error bars indicate 95% confidence interval.

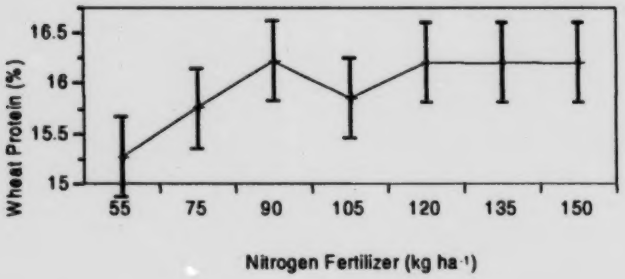


Figure 13. Wheat protein as influenced by nitrogen fertilizer (kg ha^{-1}). Error bars indicate 95% confidence interval.

Nitrogen fertilizer did not significantly affect canola yield. However, grain nitrogen increased (P=0.034) from 20 to 24% at rates of 60 and 120 kg ha^{-1} respectively. Wheat yield increased linearly with soil nitrate nitrogen measured in fall 2000 (Figure 14). Canola yield was related to (P<0.0001) soil nitrate nitrogen according to a quadratic relationship.

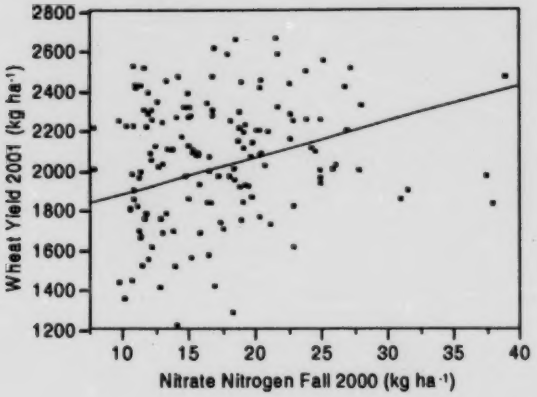


Figure 14. Wheat yield 2001 (kg ha^{-1}) as related to soil test nitrate measured in nitrogen fall 2000 (kg ha^{-1}).

Nitrogen removed as grain in 2000 was not significantly related to wheat or canola yield in 2001. It was significantly negatively correlated (P=0.0001) with nitrogen removed as grain in 2001 (Figure 15) for data combined from canola and wheat.

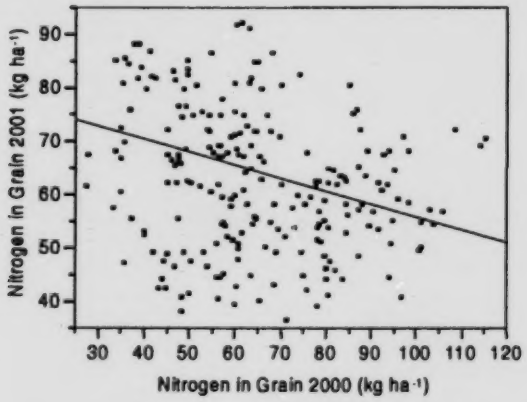


Figure 15. Correlation of nitrogen removed as grain (kg ha^{-1}) in 2000 and 2001.

Discussion

Nitrogen removed, as grain may not suitable indicator for variable rate management given the negative correlation observed in 2000 and 2001. Wheat and wheat protein were significantly related to fertilizer application in 2001, though there response observed for canola. Further research is required to identify an indicator for variable rate management.

References

1. Anonymous,1993. F.A.R.M. phase II user's guide: moisture/target yield & economic analysis utility software version 2.0 Saskatchewan, Alberta & Manitoba. Enviro-test Labs, Saskatoon, SK.

2. Beckie, H.J., Moulin, A.P. and Pennock, D.J. 1997. Strategies for variable rate nitrogen fertilization in hummocky terrain. Can. J. Soil Sci. 77:589-595

3. Cahn, M. D., Hummel, J. W., and Brouer, B. H. 1994. Spatial analysis of soil fertility for site-specific crop management. Soil Science Society of America Journal. 58:1240-1248

4. Culley J.L.B. 1993. Densith and Compressibility. pages 529-539 in M.R. Carter ed. Soil sampling and methods of analysis. Canadian Society of Soil Science, Lewis Publishers. Boca Raton, Florida.

5. Durant, L. and Fuller, L. 1998. Nitrogen Response Variability in Manitoba Soil-Landscapes. Proceedings, Annual meeting of the Manitoba Society of Soil Science. Winnipeg, Manitoba, p 8-22.

6. Engel, R. E., Long, D. S., Carlson, G. R., and Meier, C. Method for precision nitrogen management in spring wheat: I fundamental relationships. Prec. Agric. 1999; 1:327-338.

7. Gregorich, E.G. and Anderson, D.W.. 1985. Effects of cultivation and erosion on soil of four toposequences in the Canadian Prairies. Geoderma 36:343-354.

8. Moulin, A.P., Anderson, D.W. and Mellinger, M. 1994. Spatial variability of wheat yield, soil properties and erosion in hummocky terrain. Can. J. Soil Sci. 74:219-228.

9. Pennock, D.L. and de Jong, E. 1990. Spatial pattern of soil redistribution in boroll landscapes, southern Saskatchewan, Canada. Soil Sci. 150:867-873.

10. Solohub, M. P., Pennock, D.J. and Walley, F.L.. 1999. Mineral nitrogen variability across and within landscape positions. p. 85-90. In: Soil and Crops Workshop Proceedings, Saskatoon, Sk, Division of Extension, Univ. of Saskatchewan, Saskatoon, Sk. Canada

11. Verity, G.E. and Anderson, D.W. 1990. Soil erosion effects on soil quality and yield. Can. J. Soil Sci. 70:471-484.

12. Viscarra Rossel, R.A. and McBratney, A.B. 1998. Soil chemical analytical accuracy and costs: implications from precision agriculture. Australian J of Experimental Agriculture 38:765-775.

Background Deep Nitrate Leaching at IHARF Precision Farming Centre

Investigator: Brian McConkey, SPARC, Swift Current, SK, mcconkeyb@em.agr.ca

Background

Leaching of nitrates is an important environmental problem for shallow wells in Saskatchewan. For parts of the field that already had higher than average amount of soil nitrates, conventional blanket applications of N fertilizer can provide more total N supply than the crop can use leading to leaching of unused nitrate during wet falls or early springs. Therefore precision application of N fertilizer so that it is not N is not inadvertently over-applied provides a way to protect the groundwater from nitrate contamination.

Owing to the heavy surface texture, the soils of the IHARF farm are not likely to be major sources of nitrate contamination to underlying groundwater. However, compared with light soils where contamination would be more of a concern, the slower movement of nitrates through the heavy soil at the IHARF farm makes it easier to find and quantify nitrate that leaches below the rooting depth. Therefore, we can use the IHARF farm to cost effectively evaluate how precision N fertilization can reduce the potential for nitrate leaching.

In fall of 1998, we measured nitrates, soil water, and soil electrical conductivity from the soil surface to a depth of 2.4 to 3 m deep. This sampling was intended to provide a background level of deep soil nitrate contamination so only 10 deep corings were made. Coring locations attempted to represent the main physiographical features of the IHARF farm.

Results

Figure 1 shows the results for a core with no evidence of deep nitrate leaching while Figure 2 shows a core with evidence of appreciable nitrate leaching in past as indicated by elevated nitrate levels below about 1.5 m depth. Some deep nitrate leaching is almost unavoidable with fallow in the rotation (as was the case in the past) since fallow keeps the soil both moist and relatively high in nitrates. The most saline part of the IHARF farm (near central water run in field 3) was associated with highest nitrates near the surface but not at depth (data not shown). This would indicate that that area, ground water movement is upward and also that crops have not been using all the nitrogen that has been applied over the years.

Future Analysis

Fall 2001 was the scheduled next analysis of deep nitrates with a new sampling plan that accounts for 1) zones that generally have similar soil and agronomic performance, 2) the zones of past nitrate leaching form 1998 sampling and, 3) locations

that have different N balances between fertilizer N application and N removed in the grain (i.e. different amounts of potentially surplus N for leaching). However, 2001 was very dry with minimal potential for leaching. Therefore, it was decided to delay deep sampling for nitrates one more year to allow greater chance for nitrate leaching.

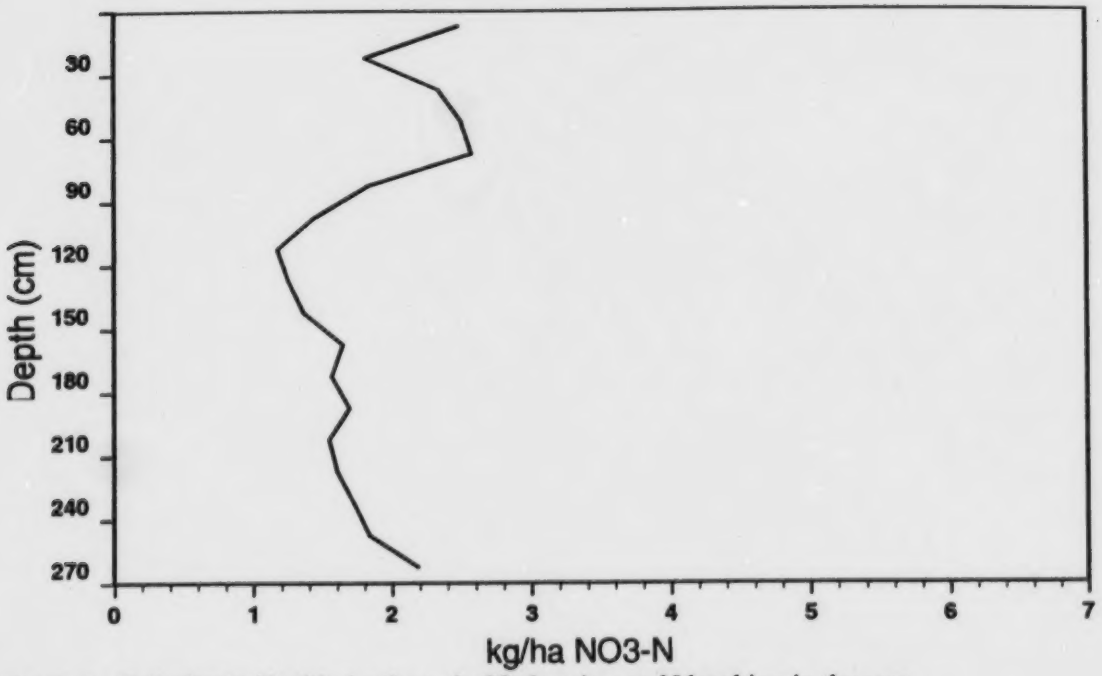


Figure 1. Soil nitrate-N with depth at pin 38 showing no N leaching in the past.

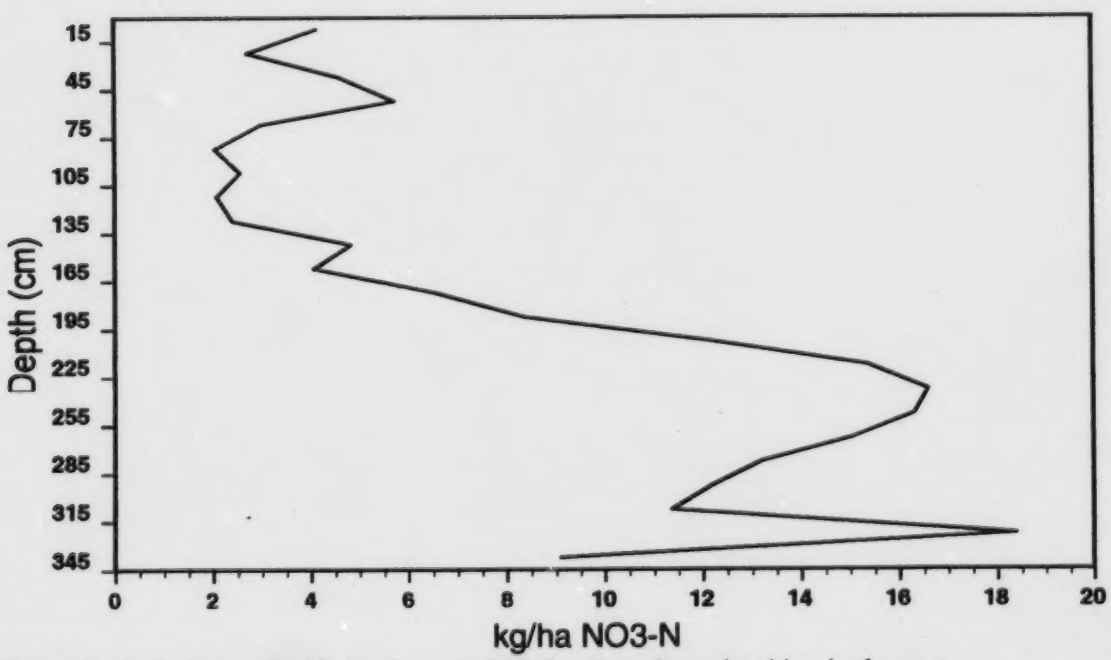


Figure 2. Soil nitrate-N with depth at pin 115 showing nitrate leaching in the past.

EM38 Study for IHARF Precision Farm.

Garth Weiterman, P. Ag., Supervisor, Agro Environmental Unit
Sask Water, Box 1000, Outlook, Sask. S0L 2N0
February 8, 2002

Summary

Sask Water's Agro Environmental Unit conducted an EM38 survey on the IHARF farm in the spring of 2001, similar to the work conducted in the fall of 1998 and the spring of 1999. The purpose of this investigation was to map any soil salinity found. A small area of the farm, associated with a water run, contained some minor salinity. Over 14,000 EM38 salinity readings were taken in both vertical and horizontal modes. Maps of salinity classes were prepared and are attached. The correlation obtained for the EM38 readings was slightly lower in 2001 than previous investigations.

Background

As part of the baseline information being collected on the IHARF farm we suggested that a non-contacting ground conductivity meter survey, commonly referred to as EM38, be undertaken. This would provide a baseline salinity map for the farm that could also be utilized in attempts to explain yield limit implications. The mapping completed in 2001 is to be used to monitor any changes in salinity that may be occurring on the farm.

Study Description

Salinity Mapping - In the fall of 1998 and again in the spring of 2001, an EM38 survey of IHARF's W1/2 28-18-12-W2 was conducted to determine the presence of soil salinity. The EM38 is mounted on a sled, pulled by an all terrain vehicle. The unit also incorporates a Differential Global Positioning System (DGPS). This enables all readings taken with the EM38 to be geo-referenced as well as exact locations of soil samples to be logged. Detailed salinity analyses are conducted on the soil samples taken and these values are regressed with the EM38 readings after the method proposed by Wollenhaupt, et.al. This data is then used in a geographic information system (GIS, ArcView 3.x) to generate a map of salinity in a vertical mode (to approximately 1.2 m) and in the horizontal mode (to approximately 0.7 m). The DGPS operates in real time and is accurate in the vertical plane to 20 cm or better thus allowing us to generate an excellent topographic map.

Soil Moisture Determination - In the spring of 1999, and again in 2001, an EM38 survey of the area was conducted to not only measure soil salinity, but soil moisture content as well. This information was to be used as a ground truthing for calibration of satellite based determination methods. The area was again mapped and soil samples were taken for gravimetric soil moisture determination. In 1999 these values were regressed with the EM38 readings to yield a soil moisture map. There was an excellent correlation of 0.96 at this time. The correlation in 2001 was only 0.41 for this exercise. The soils were much drier in the spring of 2001 than they were in 1999 and this is thought to be the reason for the disappointing regression.

Results and Discussion

There exists a small area of salinity in the slight to moderate range on the northerly quarter of the IHARF farm. It is associated with the lower draw, angling northeast, across this quarter. Yield declines in this area would vary dependant upon the salt tolerance of the crop chosen.

Comparing the 1999 and 2001 salinity maps would appear to indicate an increase in the area mapped as slightly saline. This is somewhat surprising considering the fact that the land has been zero-tilled for a number of years. We are working with the farm manager to compare salinity levels with yield information.

Future Work

It has been proposed that we conduct EM38 salinity surveys again at some point, probably in another two years, to monitor the effect of zero-tillage on the salinity present.

Attachments

EM38 vertical and horizontal salinity maps, and elevation map.

Figure 1. Horizontal EM 38 surface.

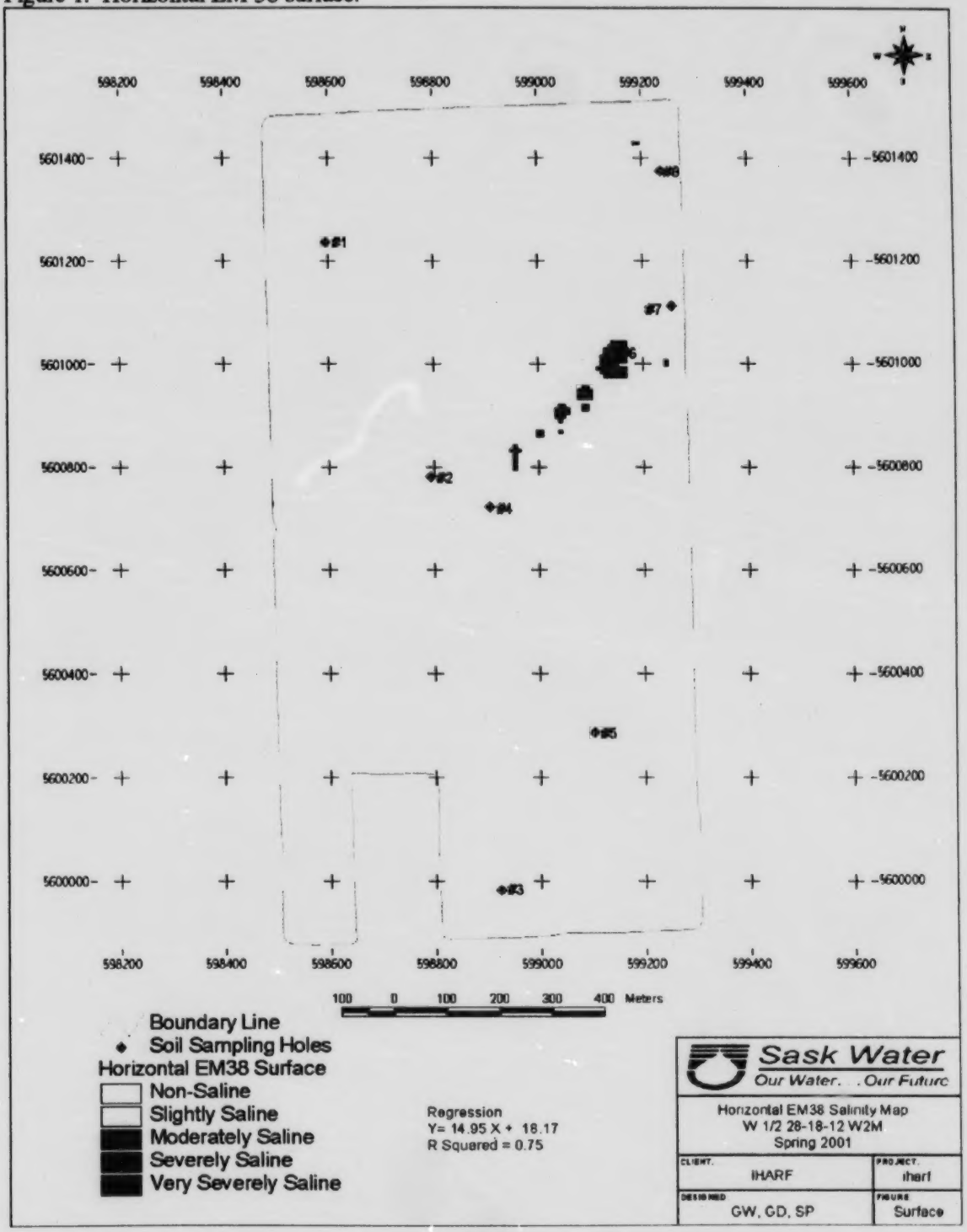
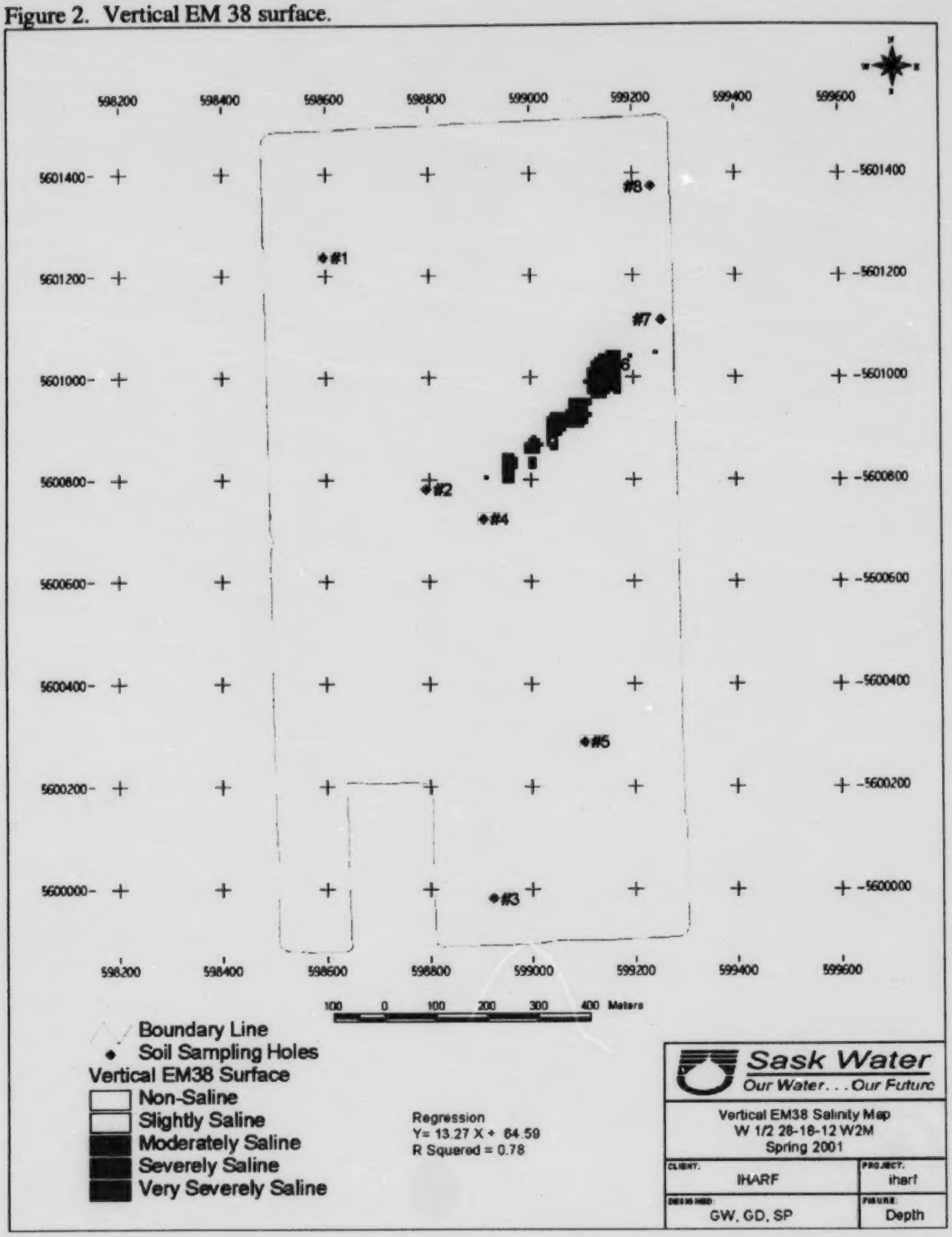


Figure 2. Vertical EM 38 surface.



Indian Head Precision Agriculture Project
Summary of 2001 Crop Yield

Yield Data Collection.

Yield data was collected at harvest using a 2001 New Holland TR 99 twin rotor combine equipped with a New Holland yield monitor connected to a Mid-Tech RX 400 P GPS receiver. The yield monitor, an Ag Leader 3000 with a New Holland face plate, registered yield mass, estimated yield and grain moisture on the go at a sub-meter accuracy provided by Omnistar DGPS correction. The first six (6) loads of every field were weighed and used for calibrating the yield monitor. Using Ag Leader SMS Basic software version 1.0,the raw yield files were exported to an ArcView.shp file format.

Using ArcView GIS 3.2, the yield data was Kriged to create the yield maps illustrated in figures 1, 2 and 3 for the wheat, canola and peas respectively.

Data Analysis.

In 2001, the average yield for the wheat, canola and peas were much lower than 2000 because of a lack of moisture. Average yields in 2000 for wheat, canola and peas were 34, 43 and 53 bushels/ac and in 2001 27, 29, 34 bushels per acre respectively. The average rainfall for the 2000 growing season was 338.8 mm and in 2001, 109.4 mm. This drought condition affected fertilizer uptake from the plants thus reducing the overall yield per acre. As noticed in all yield maps, topography had the most effect on yields. The highest yields were found in the depression areas and the lowest yields were found on the highest elevation areas for all crops due to soil moisture content.

Furthermore, fields seeded to the same crop had lower yields on the north quarter than the south quarter. For example, there was a 10 bushel/ac difference between field 3 and field 8 for canola and 24 bushels/ac difference between field 1 and 6 for the peas. Different results were observed with the wheat where field 4 and 7 had similar average yields (30.64 bu/ac and 31.86 bu/ac respectively) and field 2 and 5 had similar average yields (23.39 bu/ac and 22.57 bu/ac respectively).

The nitrogen prescription maps for wheat and canola were based on a one-acre grid. Seven rates of nitrogen (55, 75, 90, 105, 120, 135 and 150) were assigned to all fields and yield data was collected using an AgLeader yield monitor and a GPS receiver. Due to the lack of moisture during the growing season, it is difficult to visually assess the effect of the different nitrogen treatments on crop yield as the crops were under stress all season and did not fully use the fertilizer in the soil.

Figure 1. 2001 Wheat yield map.

Figure 2. 2001 Canola yield map

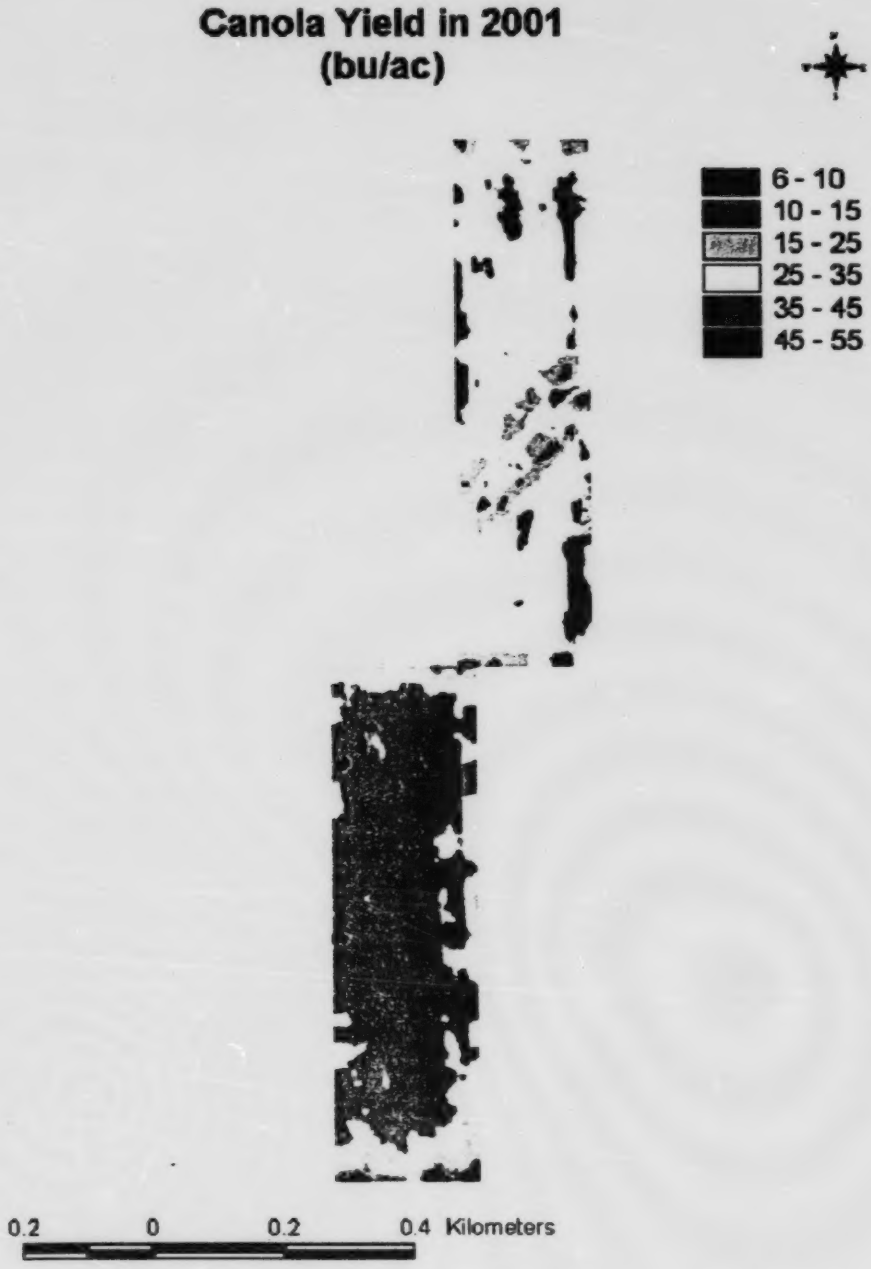
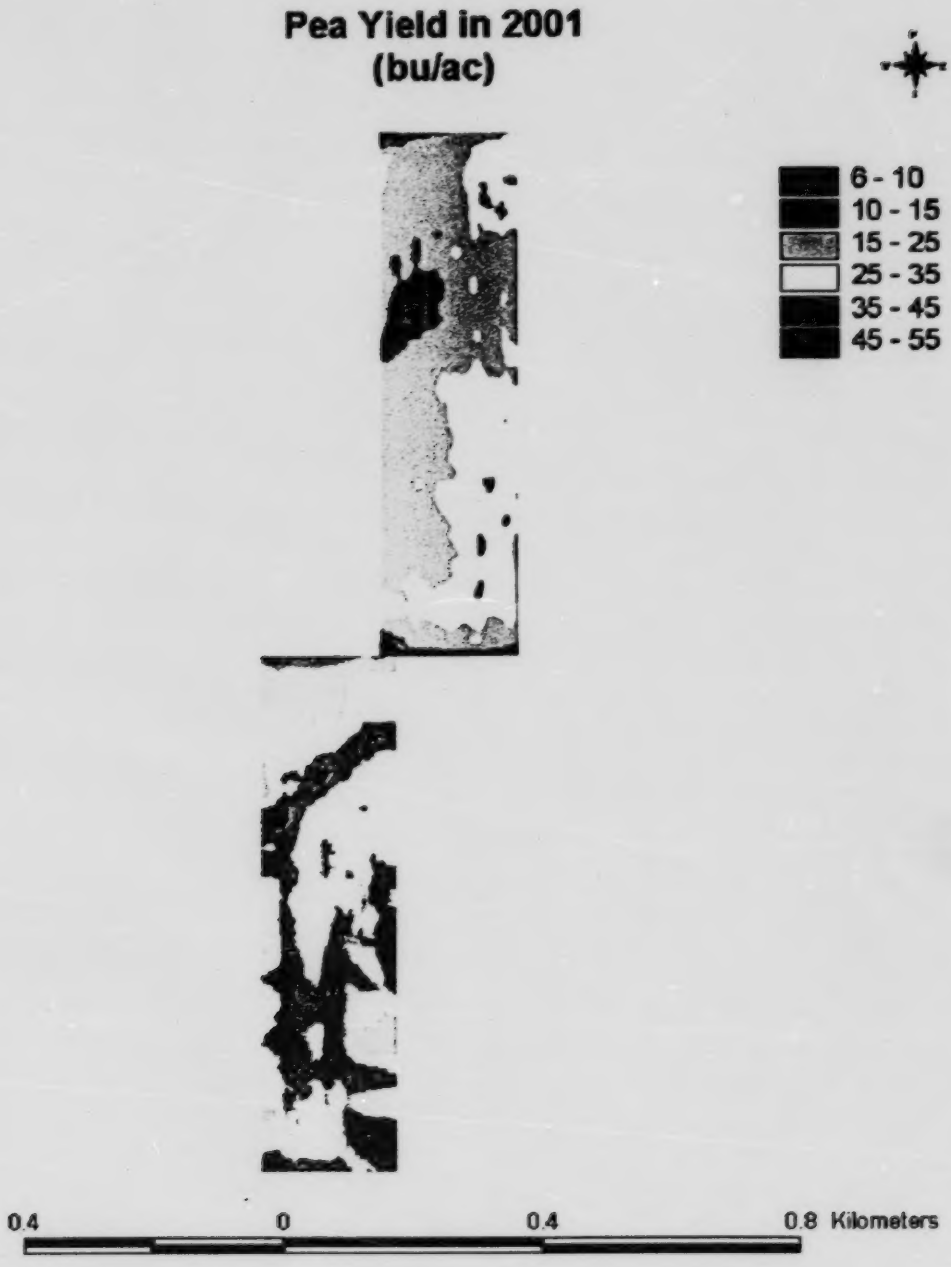


Figure 3. 2001 Pea yield map



Weed Research
Indian Head Precision Agriculture Project
Summary of Activities
2001

Weed Survey

On May 30th, 2001 weed species within 0.25m^2 quadrats were identified and counted by species before spraying. Four quadrats were assessed at each of the 308 pin locations with one quadrat sampled at a distance 1 metre north, south, east, and west of the pins.

Eleven species were differentiated within the field. Species had annual, winter annual, and perennial life cycles with some being volunteer crops. Total weed density and diversification was much lower in 2001 than any other year because of the very dry conditions that occurred that season.

Data Analysis

Using a spreadsheet format, raw data was entered per quadrat and mean, frequency, and relative abundance values calculated for each species per pin location. Using ArcView 3.2 GIS software, the plants per meter square of each species was interpolated using a spline function to create density maps. Included in this report are maps of total weed density (Figure 1), maps of Canada Thistle density (Figure 2), Dandelion density (Figure 3), Green Foxtail density (Figure 4) and Wild Oat density (Figure 5) for 1999, 2000 and 2001. The total weed density map (Figure 1) showed a high weed concentration on fields 1,3,6 and 8 due to a high count of volunteer wheat plants overshadowing the other weed counts.

Canada thistle population decreased from 1999 to 2001 from a range of 0 to 81 plants/ m^2 in 1999 to a range of 0 to 6 plants/ m^2 in 2001 (Figure 2). The highest density of Canada thistle was found in wheat field each year. As well, a few definite weed patches reoccurred at the same location each year but with a decreasing density as on the north side of the yard and the northeast corner of field 8.

Dandelion population decreased from 1999 to 2000 and was similar in 2000 and 2001. Weed patches tended to be randomly distributed throughout the field each year with no spatial distribution consistency (Figure 3).

Green foxtail population drastically decreased from 1999 to 2001 from a range of 0 to 314 plants/m^2 in 1999, 0 to 34 plants/m^2 in 2000 and 0 to 4 plants/m^2 in 2001. Definite weed patches reoccurred at the same location every year but at lower density as noticed in field 2,3 and 4 (Figure 4). Green Foxtail density seem to be affected by soil moisture conditions as 1999 and 2000 were wetter years than 2001 and the number of

weed patches and the density of weeds/patches were much greater in 1999-2000 than in 2001.

Similar to the last 3 weed species, the Wild Oat population was at the highest in 2000 because of favourable growing conditions and at its lowest in 2001 because of poor soil available moisture (Figure 5). One very noticeable trend is the re-occurrence of Wild Oat patches at the exact same location (Field 1, 3 and 7) each year.

Figure 1: 2001 Total Weed Density.

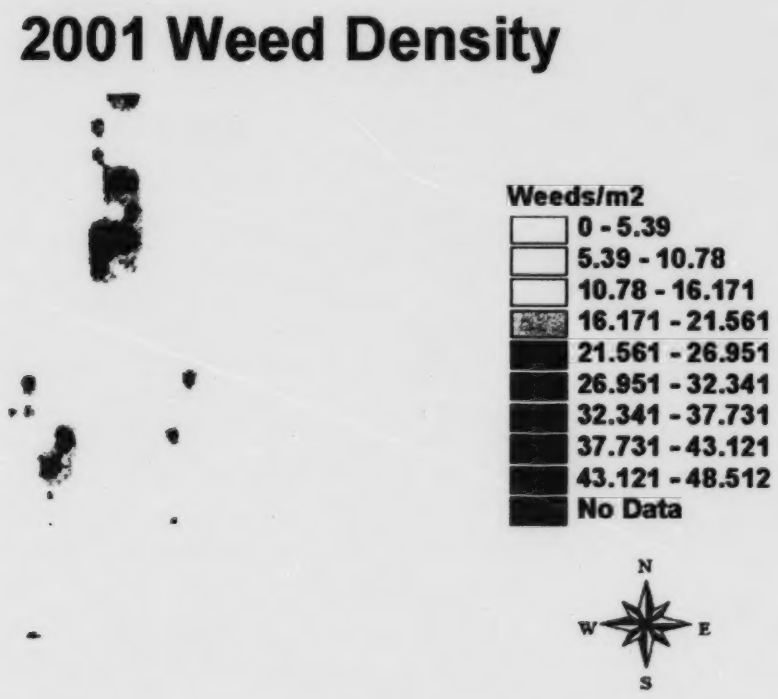


Figure 2: Canada Thistle density map comparison for 1999, 2000 and 2001.

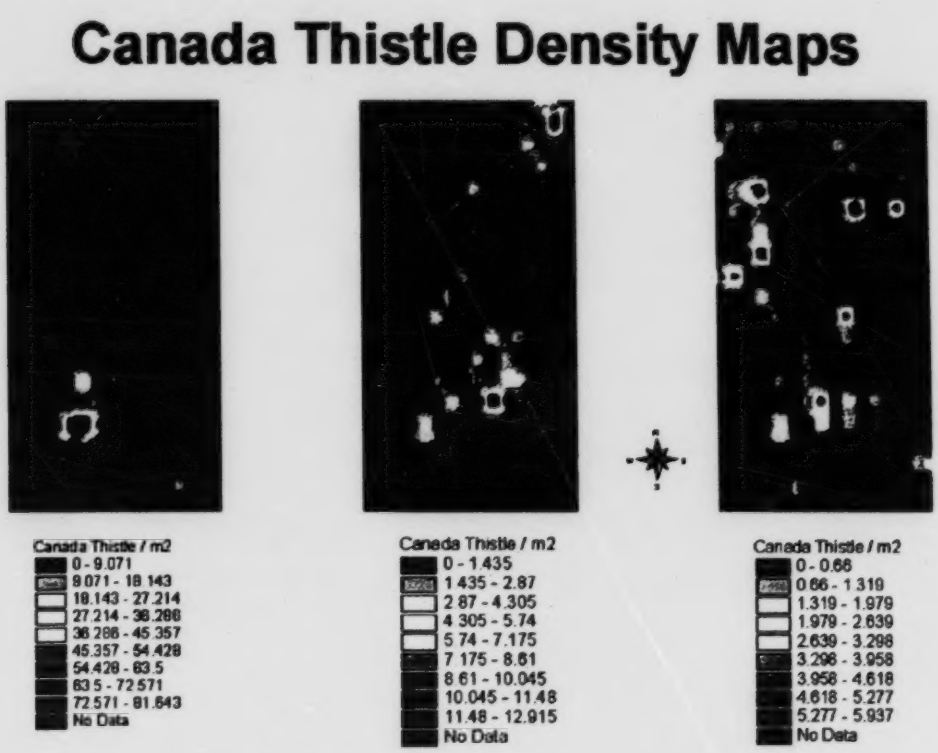


Figure 3: Dandelion density map comparison for 1999, 2000 and 2001.

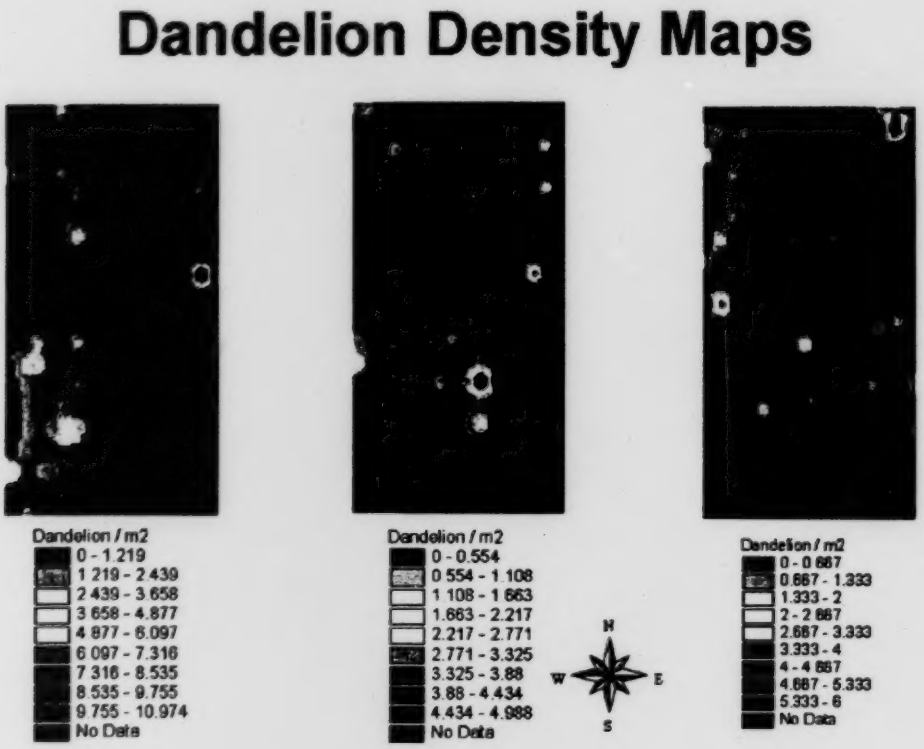


Figure 4: Green Foxtail density map comparison for 1999, 2000 and 2001.

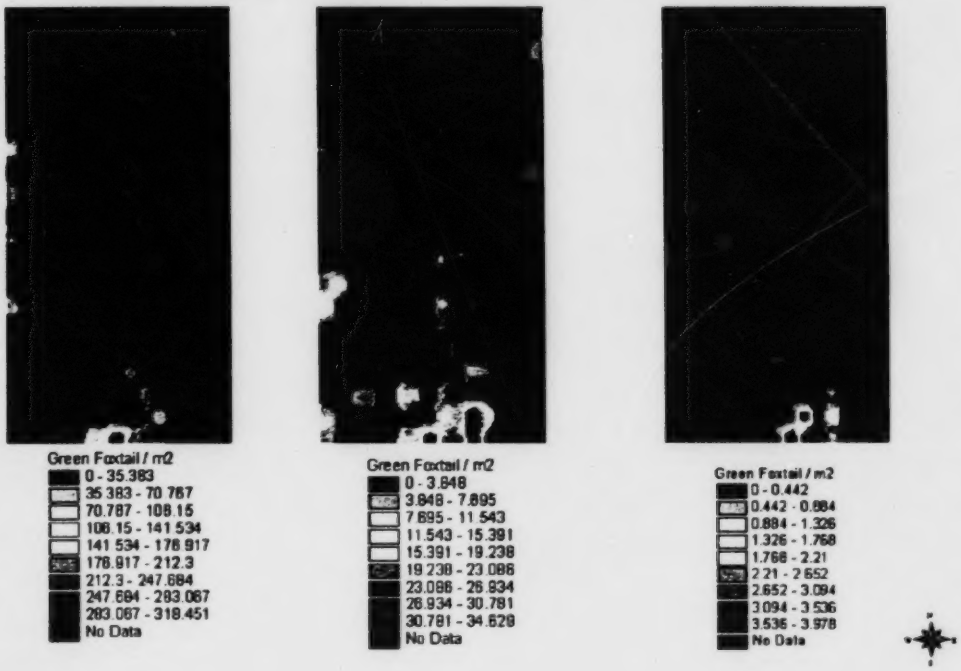
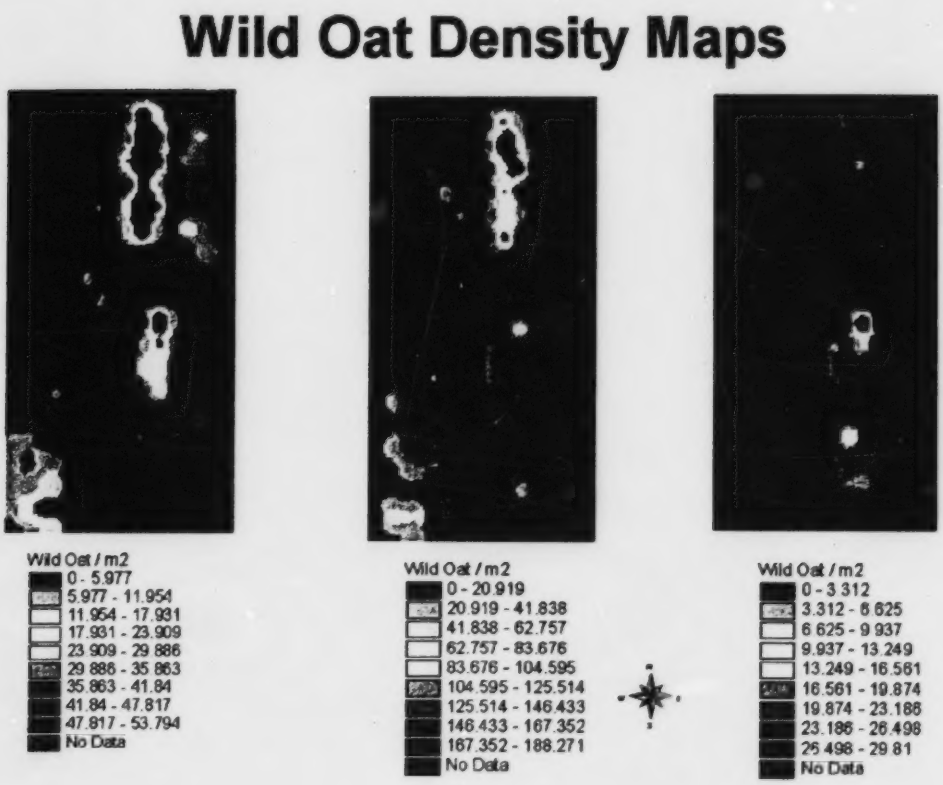


Figure 5: Wild Oat density map comparison for 1999, 2000 and 2001.



Profitability Evaluation of the IHARF Precision Farm Since 1998.

Introduction

One of the advantages of using GPS and yield monitor technology at harvest is the ability to map the yield variability on the go and to create yield maps. The yield information collected at harvest can be used, in conjunction with the Saskatchewan crop planning guide, to create "Money Maps" or "profitability maps" to illustrate profitable and non-profitable areas of a field.

The first step is to calculate the break-even bushel yield per acre needed to cover variable expenses and total expenses for a crop using the Saskatchewan crop planning guide for the year of interest. The second step is to use these figures to re-classify the yield map into 3 different classes: Class 1 - yield didn't cover direct cost, Class 2 - yield covered total costs and Class 3 - return to equity and create a money map (Appendix A). The third step is to query the "money map" to have an estimate of the area or percentage of the field for each class.

In 1998 and 1999 the Precision Farm was managed conventionally with a blanket application of fertilizers and crop protection products in a direct seeding system. In 2000 and 2001, a variable rate application program of liquid nitrogen was developed for the wheat and canola fields along with a blanket application of phosphate and sulfur fertilizers and crop protection products (refer to Appendix B for all cropping management practices from 1998 to 2001).

The crop break-even bushels per acre values for 1998, 1999, 2000 and 2001 were calculated using the exact cost for the seed and fertilizers at time of seeding (spring of each year), the average price for the crops sold and default values from the crop planning guide of the year of interest for all other expenses (refer to Appendix C for further details on commodity, seed and fertilizer prices and calculations). In 2000, each treatment was analyzed separately to obtain the break-even bushel/ac figures per treatment and overall field profitability was based on the comparisons between uniform and overall average of the variable rate strips. An application of Folicur was applied to the north and south third of fields 6 and 8. This application was taken into the profitability analysis.

Profitability Analysis

1998 Crop Production

Wheat:

Wheat production in 1998 was profitable as 88.1% of field 1 and 87% of field 6 showed a return to equity. The remaining areas of both fields showed a total cost recovery with no direct loss of profit.

Canola:

Canola production in 1998 was also profitable as fields 4 and 5 showed a net return of 70.9% and 54.3% of total area of the field respectively. 27.3% and 44.5% of total area of field 4 and 5 had yields that covered only costs and 1.8% and 1.3 % of the field areas respectively showed yield where revenues did not cover direct costs of production.

Peas:

Field pea production in field 2 was more profitable than in field 7 as 61.1% of the total area of field 2 showed a return to equity as compared to 10.3% for field 7. Total costs of production were recovered on 38.5% of field 2 and 61% of field 7 and an area of 28.7% of field 7 did not cover direct costs of production.

1999 Crop Production

Wheat:

Wheat production in 1999 was also profitable as 67.2%, 82.4%, 89% and 40.7% of fields 2,4,5 and 7 showed a net return and 32.6%, 17.3%, 10.9% and 57.3% of same fields had yields that covered only the cost of production. Very little or no areas of each field showed a negative revenue.

Canola:

Canola was the most profitable of all crops in 1999 as 88.8% and 99.8% of fields 1 and 6 showed a return to equity with 9.9% of the remaining areas of field 1 having yields that covered only the cost of production.

Peas:

Peas was the second most profitable crop grown in 1999 as 94.8% and 86.1% of fields 3 and 8 showed a net return and 3.9% and 8% of the respective field areas only covered costs. Field 3 seemed a little more profitable than field 8 as only 1.3% of the area of field 1 showed a revenue loss as compare to 5.9% of field 8. Parts of field 3 yield data was missing as yield monitor problems occurred during harvest.

2000 Crop Production

Wheat:

Profitability of wheat production in 2000 varied from field to field although general trends were apparent. In all four wheat fields, the return to equity increased from low to medium to high uniform N rate.

The north and south third of field 6 and 8 received an extra application of Folicur, a foliar fungicide. Break-even bushel/ac figures had to be calculated for the different part of those fields to accurately represent the profitability of the wheat production. In general, wheat production covered total costs in untreated areas but showed a return to equity when treated with Folicur. Furthermore, an increase in nitrogen application for the uniform strips showed a definite increase in return to equity in both Folicur treated and untreated plots. A very small area of each field showed a negative return that became insignificant when looking at the overall profitability of the wheat fields. More than 60% of the area of each variable rate strip of nitrogen in each of the fields covered total costs and 20% of the remaining area showed a return to equity.

Canola:

Canola production showed a net return on over 82% of the area of both fields in the uniform and overall average of the variable rate strip, with little or no revenue loss. The variable rate strips showed an increasing return to equity with an increase in nitrogen rate.

Peas:

Pea production showed a return to equity in 80.8 to 96.9 % of total field area of field 4 and 5 respectively. The difference in seeding rate (2 and 3 bushels/ac) did not have a significant effect on the profitability of field pea production.

2001 Crop Production
Wheat:

Profitability of wheat production in 2001 varied with the different nitrogen rates. In general, wheat production covered costs in 60% to 80% of the total field area in all fields. Return to equity was less than 10% of field area for all fields, and higher nitrogen rates (135 lbs n/ac and 150 lbs n/ac) showed an increasing revenue loss per area than the rest of the treatments. This phenomenon can be attributed to the low precipitation levels experienced during the 2001 growing season which did not allow the wheat crop to fully utilized the available nitrogen fertilizer.

Canola:

Canola showed an impressive return to equity in all nitrogen treatments due to high commodity prices. Return to equity varied from 87% to 100% of N treatment plots with as little as 0% to 10% area that covered total costs.

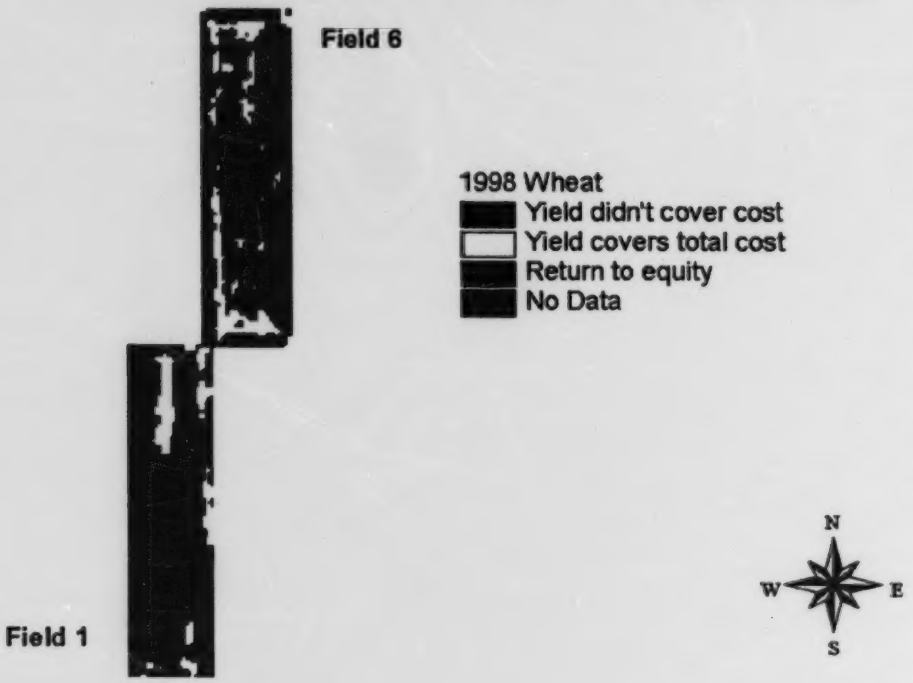
Peas:

Pea production had a greater return to equity in field 1 than field 6 due to the difference in soil available moisture present in field 1. However both fields showed a good return to equity (above 80% of field 1 and above 50 % of field 6) and no significant difference between seeding rates.

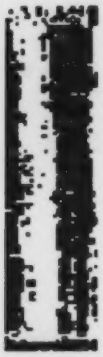
Appendix A

Profitability Maps of the IHARF Precision Farm.

1998 Wheat Profitability Map.



1998 Canola Profitability Map.

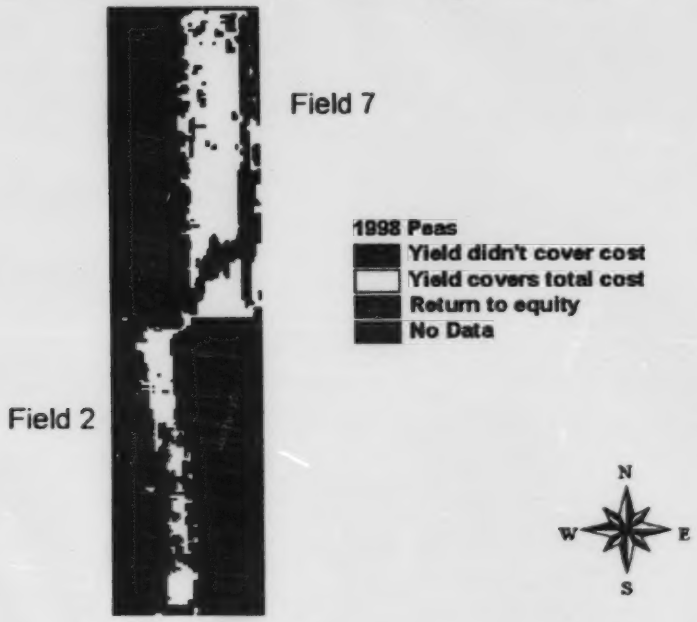


Field 5

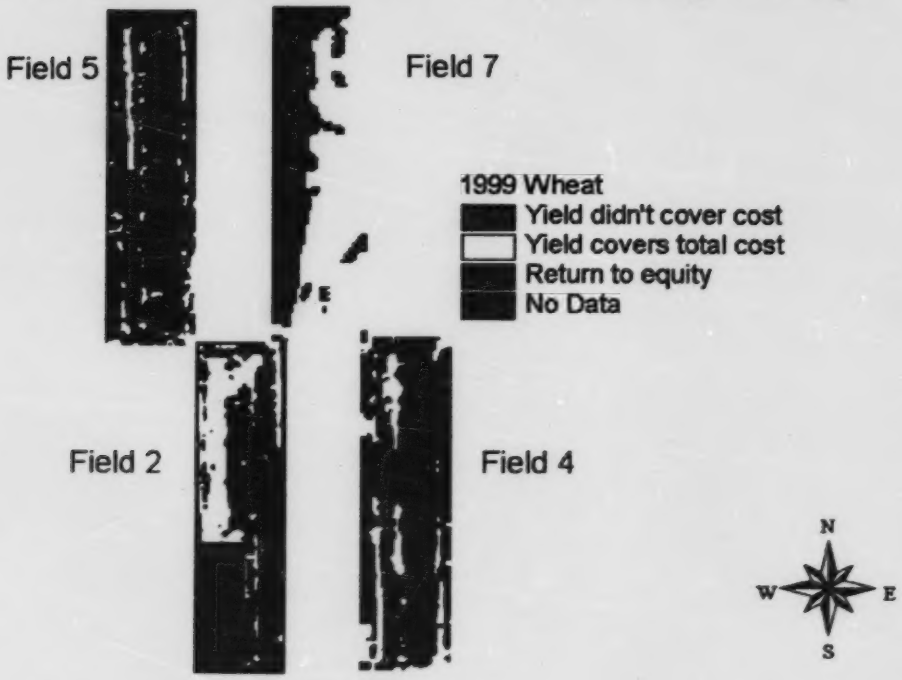
Field 4

1998 Canola
Yield didn't cover cost
Yield covers total cost
Return to equity
No Data

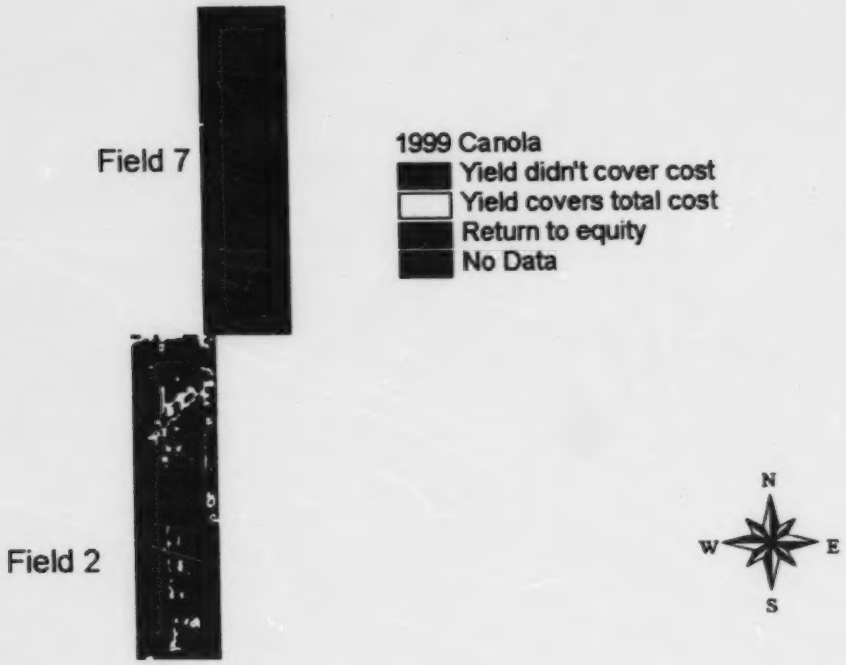
1998 Peas Profitability Map.



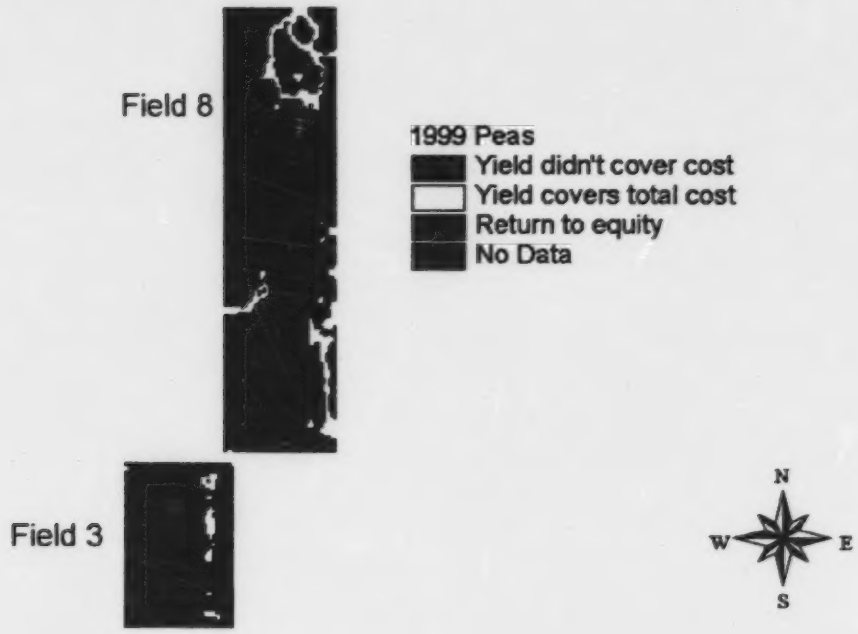
1999 Wheat Profitabilty Map.



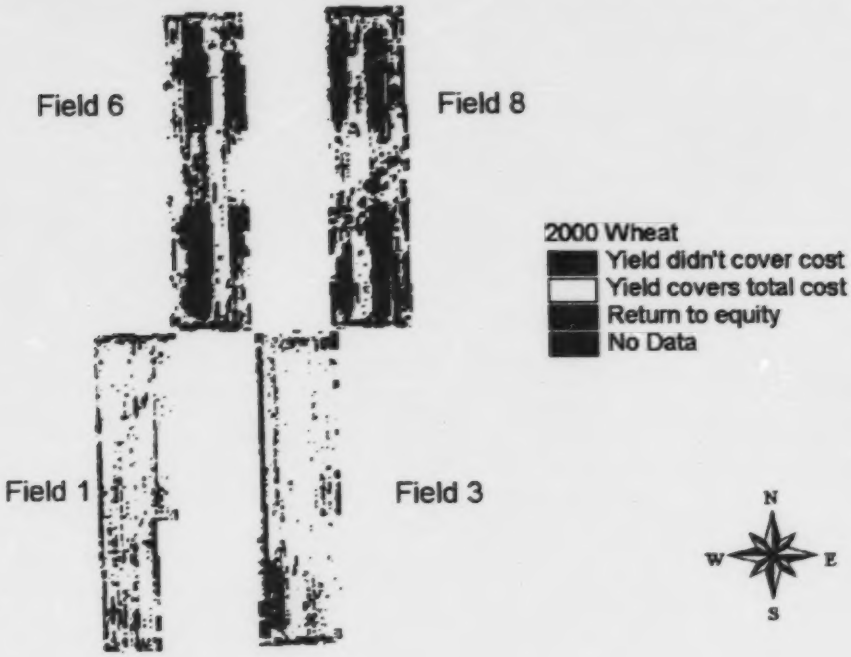
1999 Canola Profitability Map.



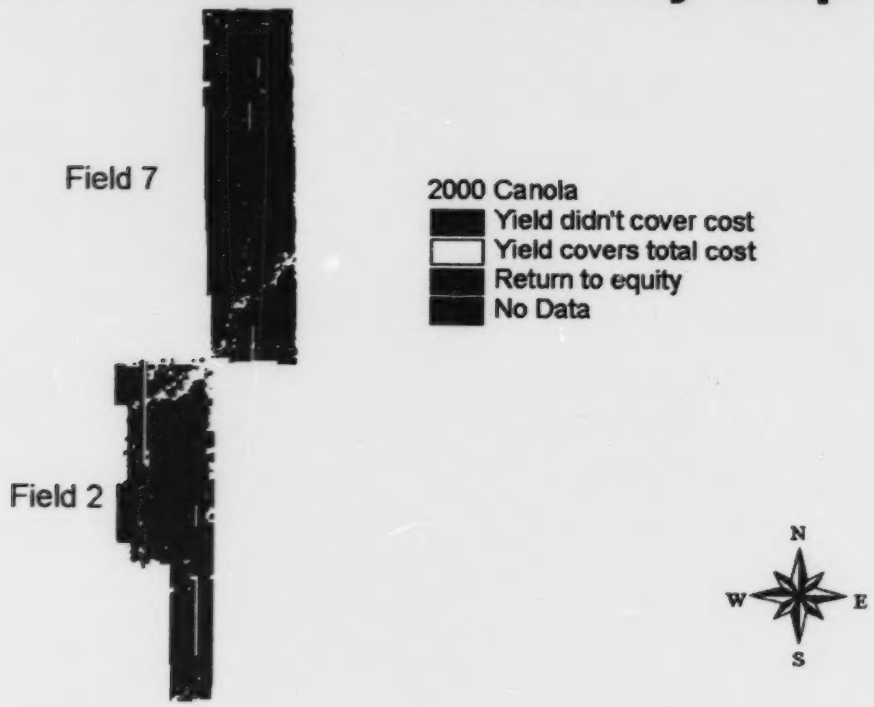
1999 Peas Profitability Map.



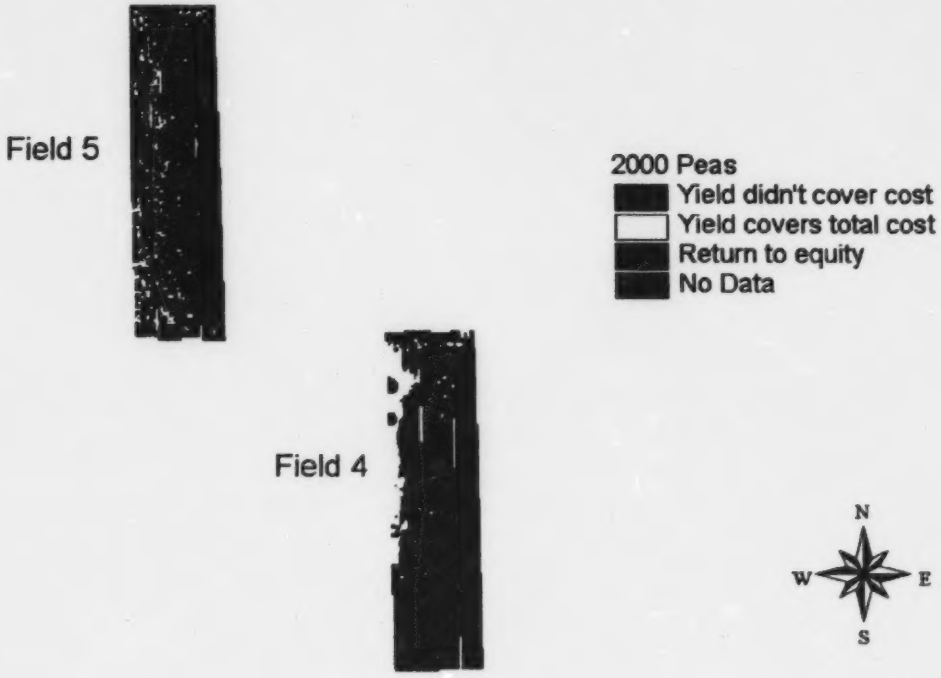
2000 Wheat Profitability Map.



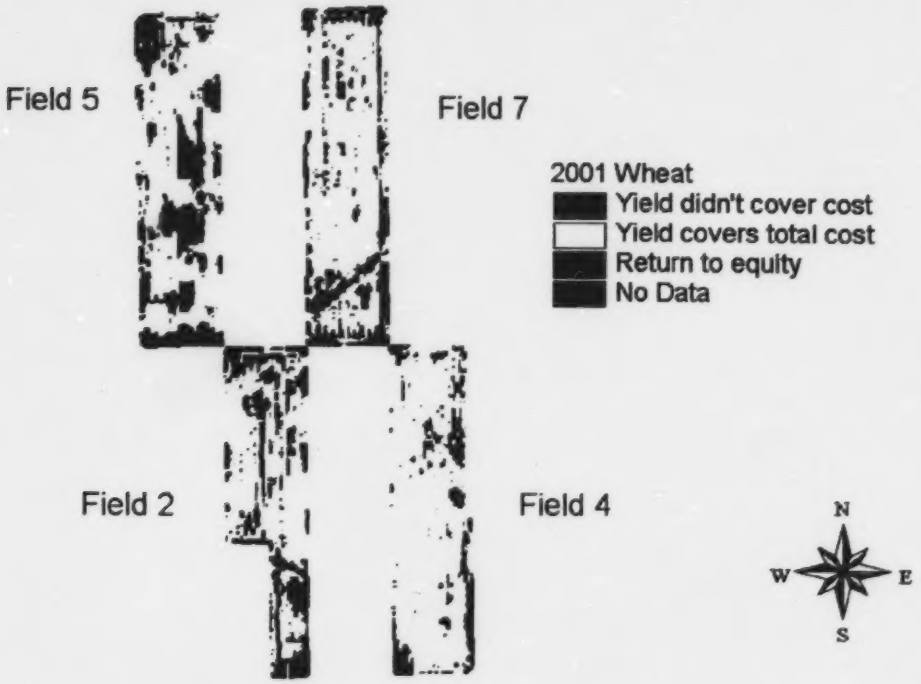
2000 Canola Profitability Map.



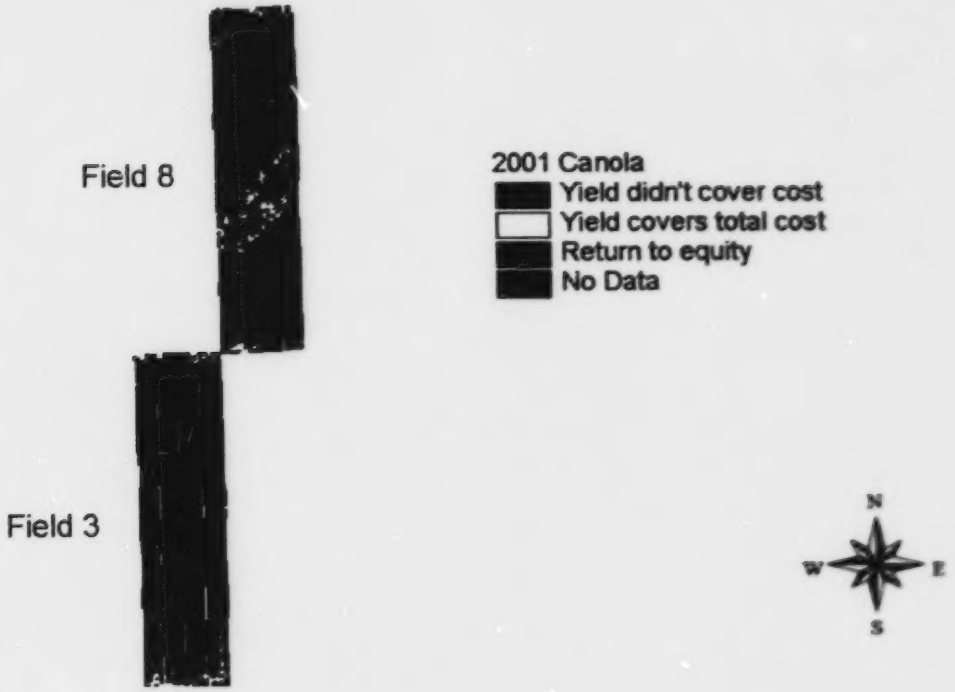
2000 Peas Profitability Map.



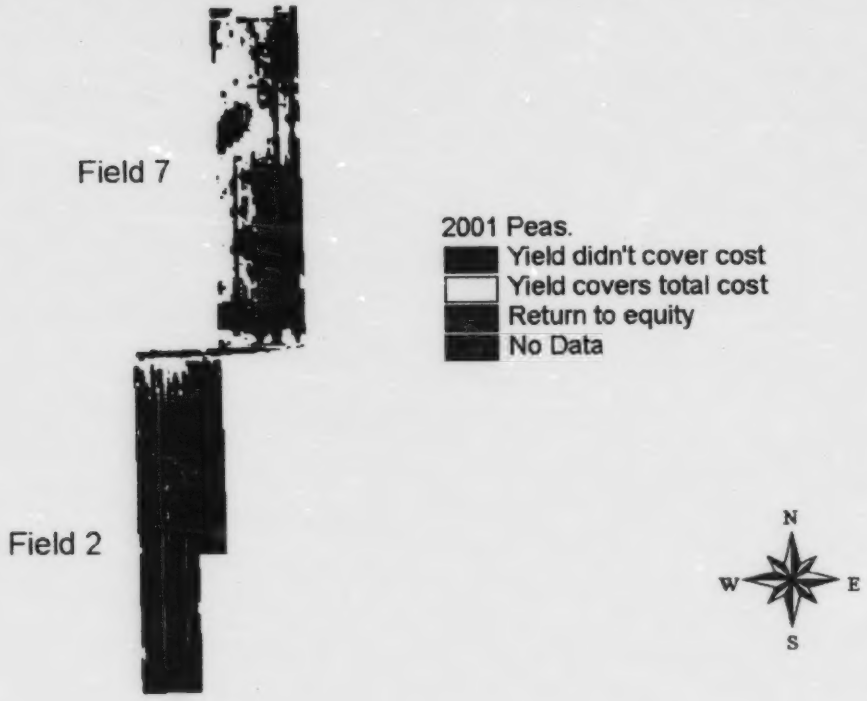
2001 Wheat Profitability Map.



2001 Canola Profitability Map.



2001 Peas Profitability Map.



Appendix B

Production Practices at the IHARF Precision Farm.

Equipment

Seeding:

33' Flexicoil 5000 Air Drill
Stealth openers with a side band stainless steel tube added on for liquid fertilizer,12" spacing
Flexicoil 1720 Air Cart
1350 Pattison Liquid Fertilizer Wagon equipped with a John Blue ground driven diaphragm pump.
2001 8970 New Holland front wheel assist tractor.

Spraying:

Pre-seeding, post-emergence and post harvest applications done with a 2001 Flexicoil 67 XL High Clearance Pull Type Sprayer

Harvesting:

2001 New Holland TR99 combine equipped with a Mid-Tech RX 400 P GPS receiver with Omnistar DGPS correction connected to the New Holland yield monitor.

Grain Transportation:

Grain transportation was done using a 1974 Cab-Over CargoStar with a 425 bushel box.

1998 Precision Farm
Report on Production Practices for 1998.

All fields were sprayed with Roundup @ 1 L/ac and 5 US gal/ac of water prior to seeding in May.

Field 1:
Seeded to Wheat
Variety: CDC Teal
Date seeded: May 14th, 1998
Seeding rate: 109 lbs/ac

Fertilizer used: 7-35-17-0
Application rate: @ 59.2 lbs/ac of product
N- Fertilizer used: 28-0-0
Application rate: side-banded @ 11.7 US gal/ac of product or 34.8 lbs actual N/ac for the whole field

Spraying Date: June 14th, 1998
Chemicals used:
Triumph Plus @ 0.33 L/ac of FM+ 4.05 g/ac of Plus
Water @ 5 US gal/ac

Harvested: August 29th, 1998

Field 2:
Seeded to Peas
Variety: Carneval
Date seeded: May 18th, 1998
Seeding rate: 185 lbs/ac
Granular Innoculant: LiphaTech @ 4.5 lbs/ac

Fertilizer used: 7-35-17-0
Application rate: Side-banded @ 59.21 lbs of product / ac

Spraying: June 15th,1998
Chemicals used:
Venture @ 0.16 kg/ac
Pursuit @ 0.05 L/ac
TurboCharge @ 0.5 L/100L of sol.
Water @ 5 US gal/ac

Harvested: August 26th, 1998

Field 3:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 13th , 1998
Seeding rate: 108 lbs/ac

Fertilizer used: 7-35-17-0
Application rate: Side-banded @ 59.2 lbs/ac of product

Spraying Date: June 14th, 1998
Chemicals used:
Triumph Plus @ 0.33 L/ac of FM+ 4.05 g/ac of Plus
Water @ 5 US gal/ac

Harvested: August 28th, 1998

Field 4:

Seeded to: Canola
Variety: Liberty Link
Date seeded: May 19th, 1998
Seeding rates: 4.24 lbs/ac

Fertilizer used 7-35-17-0
Application rate: Side-banded @ 59.2 lbs/ac of Product
N- Fertilizer used: 28-0-0
Application rate: Side-banded @ 22.8 US gal/ac of Product or 62.4 lbs actual N / ac for the whole field

Spraying Date: June 25th, 1998
Chemicals used:
Liberty @ 1.35 L/ac
Venture 25 DG @ 0.08 kg/ac
TurboCharge @ 0.1 L/100 L of sol.
Water @ 10 US Gal /ac

Harvested: September 2nd, 1998.

Field 5:
Seeded to Canola
Variety: Liberty Link
Date seeded: May 20th , 1998
Seeding rates: 4.24 lbs/ac

Fertilizer used: 7-35-17-0
Application rate: Side-banded @ 59.2 lbs/ac of product
N- Fertilizer used: 28-0-0
Application rate: Side-banded @ 13.9 US gal/ac of product or 33.3 lbs actual N/ac for the whole field

Spraying Date: June 25th, 1998
Chemicals used:
Liberty @ 1.35 L/ac
Venture 25 DG @ 0.08 kg/ac
TurboCharge @ 0.1 L/100 L of sol.
Water @ 10 US Gal /ac

Harvested: September 3rd, 1998

Field 6:
Seeded to Wheat
Variety: CDC Teal
Date seeded: May 14th , 1998
Seeding rates: 109 lbs/ac

Fertilizer used : 7-35-17-0
Application rate: Side-banded @ 59.2 lbs/ac of product
N- Fertilizer used: 28-0-0
Application rate: Side-banded @ 18.5 US gal/ac of product or 55.1 lbs actual N/ac for the whole field

Spraying Date: June 14th, 1998
Chemicals used:
Triumph Plus @ 0.33 L/ac of FM+ 4.05 g/ac of Plus
Water @ 5 US gal/ac

Harvested: August 29th, 1998

Field 7:
Seeded to Peas
Variety: Carneval
Date seeded: May 18th, 1998
Seeding rates: 185 lbs/ac
Granular Innoculant: 4.5 lbs/ac

Fertilizer used: 7-35-17-0
Application rate: Side-banded @ 59.21 lbs of product/ac

Spraying: June 15th,1998
Chemicals used:
Venture @ 0.16 kg/ac
Pursuit @ 0.05 l/ac
TurboCharge @ 0.5 l/100l of sol.
Water @ 5 US gal/ac

Harvested: August 27th, 1998

Field 8:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 13th, 1998
Seeding rates: 108 lbs/ac

Fertilizer used: 7-35-17-0
Application rate: Side-banded @ 59.2 lbs/ac of product
N- Fertilizer used: 28-0-0
Application rate: Side-banded @ 18.5 US gal/ac of product or 55.1 lbs actual N / ac for the whole field

Spraying Date: June 14th, 1998
Chemicals used:
Triumph Plus @ 0.33 L/ac of FM+ 4.05 g/ac of Plus
Water @ 5 US gal/ac

Harvested: August 28th, 1998

All fields were sprayed with 2,4 D Ester LV 700 @ 0.33 L/ac + 5 US gal /ac of water on October 20th , 1998.

1999 Precision Farm
Report on Production Practices for 1999.

All fields were sprayed with Touchdown @ 0.8 L/ac and 5 US gal/ac of water prior to seeding.

Field 1:

Seeded to Canola
Variety: Liberty Link 2153
Date seeded: May 29thrd, 1999
Seeding rates: 6.4 lbs/ac
Seed Treatment: Counter 5G @ 5 lbs/ac

P- Fertilizer used: 12-51-0
Application rate: Side-banded @ 78 lbs/ac of product or 40 lbs actual P/ac for the whole field
N- Fertilizer used: 28-0-0
Application rate: side-banded @ 32 imp gal/ac of product or 140 lbs actual N/ac for the whole field

Spraying Date: June 29th, 1999
Chemicals used:
Liberty @ 1.35 L/ac
Venture @ 0.06 kg/ac
TurboCharge @ 0.5 L/100 L of sol.
Water @ 5 US Gal/ac

Harvested: October 2nd, 1999

Field 2:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 28th, 1999
Seeding rates: 120 lbs/ac

Fertilizer used: 12-51-0
Application rate: Side-banded @ 48 lbs/ac of product or 24.5 lbs actual P / ac for the whole field
N- Fertilizer used: 28-0-0
Application rate: Side-banded @ 30 Imp gal/ac of product or 115 lbs actual N/ac for the whole field

Spraying Date: June 29th, 1999
Chemicals used:
Triumph Plus @ 0.33 l/ac of FM+ 4.05 g/ac of Plus
Water @ 5 US gal/ac

Harvested: October 20th, 1999

Field 3:
Seeded to Peas
Variety: Carneval
Date seeded: June 3rd,1999
Seeding rates: 170 lbs/ac
Granular Innoculant: LiphaTech @5 lbs/ac

Fertilizer used: 12-51-0
Application rate: Side-banded @ 48 lbs of product/ac or 24.5 lbs actual P/ac for the whole field
N- added by using 12-51-0 5.76 lbs actual N/ac

Re-seeding date: June 22nd, 1999
Acres re-seeded: 11.8 ac
Seeding Rate: 174 lbs/ac
Granular Innoculant: LiphaTech @5 lbs/ac
Fertilizer used: 12-51-0
Fertilizer Rate: side-banded @ 49 lbs/ac of product or 25 lbs of P/ac.

Spraying Date for early seeded: June 29th, 1999
Spraying date for re-seeded area: July 14th, 1999
Chemicals used:
Odyssey @ 17.3 g/ac
Merge @ 0.5 l/ 100 l of sol
Water @ 5 US gal/ac

Harvested: September 24th, 1999 (early seeded)
October 22nd, 1999 (re-seeded)

Field 4:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 29th, 1999
Seeding rates: 120 lbs/ac

Fertilizer used: 12-51-0
Application rate: Side-banded @ 48 lbs/ac of product or 24.5 lbs actual P/ac for the whole field
N- Fertilizer used: 28-0-0
Application rate: side-banded @ 30 Imp gal/ac of product or 115 lbs actual N/ac for the whole field

Spraying Date: June 29th, 1999
Chemicals used:
Triumph Plus @ 0.33 l/ac of FM+ 4.05 g/ac of Plus
Lontrel @ 0.1 L/ac
Water @ 5 US gal/ac

Harvested: October 15th, 1999

Field 5:
Seeded to Wheat

Variety: AC Barrie
Date seeded: May 28th, 1999
Seeding rates: 120 lbs/ac

Fertilizer used: 12-51-0
Application rate: Side-banded @ 48 lbs/ac of product or 24.5 lbs actual P/ac for the whole field
N- Fertilizer used: 28-0-0
Application rate: side-banded @ 30 Imp gal/ac of product or 115 lbs actual N/ac for the whole field

Spraying Date: June 29th, 1999
Chemicals used:

Triumph Plus @ 0.33 l/ac of FM+ 4.05 g/ac of Plus
Lontrel @ 0.1 l/ac
Water @ 5 US gal/ac

Harvested: October 8th, 1999

Field 6:
Seeded to Canola
Variety: Liberty Link 2153
Date seeded: May 29th, 1999
Seeding rates: 6.4 lbs/ac
Seed Treatment: Counter 5G @ 5 lbs/ac
Fertilizer used : 12-51-0
Application rate : Side-banded @ 78 lbs/ac of product or 40 lbs actual P/ac for the whole field
N- Fertilizer used: 28-0-0
Application rate : Side-banded @ 32 Imp gal/ac of product or 140 lbs actual N / ac for the whole field

Spraying Date: June 29th, 1999
Chemicals used:

Liberty @ 1.35 l/ac
Venture @ 0.06 kg/ac
TurboCharge @ 0.5 L/100 L of sol.
Water @ 5 US Gal/ac

Harvested: October 3rd, 1999

Field 7:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 28th, 1999
Seeding rates: 120 lbs/ac

Fertilizer used: 12-51-0
Application rate: Side-banded @ 48 lbs/ac of product or 24.5 lbs actual P/ac for the whole field
N- Fertilizer used: 28-0-0
Application rate: side-banded @ 30 Imp gal/ac of product or 115 lbs actual N/ac for the whole field

Spraying Date: June 30th, 1999
Chemicals used:
Triumph Plus @ 0.33 L/ac of FM+ 4.05 g/ac of Plus
Water @ 5 US gal/ac

Harvested: October 20th, 1999

Field 8:
Seeded to Peas
Variety: Carneval
Date seeded: June 3rd, 1999
Seeding rates: 170 lbs/ac
Granular Innoculant: LiphaTech @5 lbs/ac

P- Fertilizer used: 12-51-0
Application rate: Side-banded @ 48 lbs of product / ac or 24.5 lbs actual P/ac for the whole field
N- Fertilizer added from 12-51-0: 5.76 lbs actual N/ac

Re-seeding date: June 22nd, 1999
Acres reseeded: 20 ac
Seeding Rate: 174 lbs/ac
Granular Innoculant: LiphaTech @5 lbs/ac
Fertilizer used: 12-51-0
Fertilizer Rate: Side-banded @ 49 lbs/ac of product or 25 lbs of P/ac.

Spraying Date for early seeded: June 29th, 1999
Spraying date for re-seeded area: July 14th, 1999

Chemicals used:
Odyssey @ 17.3 g/ac
Merge @ 0.5 L/ 100 L of sol
Water @

Harvested: October 22nd, 1999

All fields were sprayed with 2,4 D on November 2nd, 1999.

2000 Precision Farm
Report on Production Practices for 2000.

All fields were sprayed with 0.5 L/ac Roundup Original in 5.0 gal/ac of water prior to seeding.

Field 4:
Seeded to Peas
Variety: Swing
Date seeded: May 3rd, 2000

Seeding rates:
Low seeding rate (LSR): 161 lbs/ac
High seeding rate (HSR): 218 lbs/ac

Seeded area per treatment: 20 acres

Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product/ac or 30 lbs actual P/ac for the whole field
Seed Innoculant: LiphaTech @ 3.8 lbs/ac

Spraying Date: June 7th, 2000
Chemicals used:
Odyssey @ 0.017 Kg/ac
Merge @ 0.5 L / 100 L sol.
Water @ 6.5 US Gal /ac

Harvested: August 23rd , 2000

Field 5:
Seeded to Peas
Variety: Swing
Date seeded: May 5th, 2000

Seeding rates:
Low seeding rate (LSR): 161 lbs/ac
High seeding rate (HSR): 218 lbs/ac

Seeded area per treatment: 20 acres

Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product / ac or 30 lbs actual P/ac for the whole field
Seed Innoculant: LiphaTech @ 3.8 lbs/ac

Spraying Date: June 7th, 2000
Chemicals used:
Odyssey @ 0.017 Kg/ac
Merge @ 0.5 L/100 L sol.
Water @ 6.5 US Gal /ac

Harvested: August 18th , 2000

Field 7:
Seeded to : Canola
Variety: Liberty Link Invigor 2573
Date seeded: May 9th, 2000
Seeding rate: 5.0 lbs/ac

P - Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product / ac or 30 lbs actual P/ac

N - Fertilizer used: 28-0-0
Treatments per field: 2 - duplicated once (refer to treatment map)
Treatment type: 1 Uniform rate and 1 Variable Rate (N rates calculated using Farm Phase II software)
Application Rates:
Uniform Treatment (U): 26.6 Imp Gal / Ac or 94 lbs N / ac
Variable Rate Zone 1 (H): 32.5 Imp gal /ac or 116 lbs of actual N/ac
Zone 2 (M): 27.2 imp gal/ac or 97 lbs of actual N/ac
Zone 3 (L): 21.3 Imp gal/ac or 76 lbs of actual N/ac
Spraying Date: June 7th, 2000
Chemicals used:
Liberty @ 1.35 L/ac
Select @ 0.026 L/ac
Amigo @ 0.5 L/100 L of Solution
Water @ 5.0 US gal/ac

Harvested: September 12th,2000

Field 2:
Seeded to: Canola
Variety: Liberty Link Invigor 2573
Date seeded: May 17th, 2000
Seeding rate: 5.0 lbs/ac
Seeded area per treatment: 10 acres

P - Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product/ac or 30 lbs actual P/ac for the whole field

S - Fertilizer used: 20.5-0-0-24
Application rate: Side-banded @ 62.5 lbs of product/ac or 15 lbs of actual S/ac for the whole field

N - Fertilizer used: 28-0-0
Treatments per field: 2 - duplicated once (refer to treatment map)
Treatment type: 1 Uniform rate and 1 Variable Rate (N rates calculated using Farm Phase II software)
Application Rates:

Uniform Treatment (U): 26.9 Imp Gal / ac or 96 lbs N / ac
Variable Rate: Zone 1 (H2): 33.4 Imp gal/ac or 119.2 lbs actual N/ac
Zone 2 (H1): 31.7 Imp gal/ac or 113.2 lbs of actual N/ac
Zone 3 (M): 26.9 Imp gal/ac or 96 lbs of actual N/ac
Zone 4 (L): 20 Imp gal/ac or 71.4 lbs of actual N/ac

Zone delineation: Done using Remote sensing satellite images of NDVI Index of 1998 and 1999

Spraying Date: June 7th, 2000
Chemicals used:

Liberty @ 1.35 L/ac
Select @ 0.026 L/ac
Amigo @ 0.5 L/100 L of Solution
Water @ 5.0 US gal/ac

Harvested: September 12th, 2000

Field 1:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 17th, 2000
Seeding rate: 120 lbs/ac

P - Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product/ac or 30 lbs actual P/ac for the whole field

N - Fertilizer used: 28-0-0 Liquid
Treatments per field: 4 (refer to treatment map)

Treatment type: 3 Uniform rate and 1 Variable Rate (N rates calculated using Farm Phase II software)
Application Rates:
Uniform Treatments :
High rate (H): 33.3 Imp gal / ac or 118 lbs of actual N/ac
Medium rate (M): 29.1 Imp gal/ ac or 103.8 lbs of actual N/ac
Low rate (L): 13.2 Imp gal/ac or 47.1 lbs of actual N/ac
Variable Rate: (VRA)
Rates varied from 15 Imp gal/ac to 37 Imp gal/ac or 53.5 lbs of N/ac to 132.1 lbs N/ac
Variable rate application map based on nitrogen removal from grain protein and yield from 1999.

Spraying Date: June 30th, 2000
Chemicals used:
Puma Super @ 0.31 L/ac
Curtail M @ 0.8 L/ac

Harvested: September 14th, 2000

Field 3:
Seeded to: Wheat
Variety: AC Barrie
Date seeded: May 20th, 2000
Seeding rate: 120 lbs/ac

P - Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product/ac or 30 lbs actual P/ac for the whole field

N - Fertilizer used: 28-0-0 Liquid
Treatments per field: 4 (refer to treatment map)
Treatment type: 3 Uniform rate and 1 Variable Rate (N rates calculated using Farm Phase II software)
Application Rates:
Uniform Treatments:
High rate (H): 20.7 Imp gal/ac or 73.9 lbs of actual N/ac
Medium rate (M): 17.4 Imp gal/ac or 62.1 lbs of actual N/ac
Low rate (L): 9 Imp gal/ac or 32.1 lbs of actual N/ac
Variable Rate (VRA):
Rates varied from 0 Imp gal/ac to 34 Imp gal/ac or 0 lbs of N/ac to 121.4 lbs N/ac
Variable rate application map based on Nitrogen removal from grain Protein and yield from 1999.

Spraying Date: June 30th, 2000
Chemicals used:
Puma Super @ 0.31 l/ac
Curtail M @ 0.8 l/ac

Harvested September 15th, 2000

Field 6:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 20th, 2000
Seeding rate: 120 lbs/ac

P - Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product/ac or 30 lbs actual P/ac for the whole field

N - Fertilizer used: 28-0-0 Liquid
Treatments per field: 4 (refer to treatment map)
Treatment type: 3 Uniform rate and 1 Variable Rate (N rates calculated using Farm Phase II software)
Application Rates:
Uniform Treatments:
High rate (H): 26 Imp gal/ac or 92.8 lbs of actual N/ac
Medium rate (M): 22.7 Imp gal/ac or 81 lbs of actual N/ac
Low rate (L): 14.3 Imp gal/ac or 51 lbs of actual N/ac
Variable Rate (VRA):
Rates varied from 0 Imp gal/ac to 30 Imp gal/ac or 0 lbs of N/ac to 107.1 lbs N/ac
Variable rate application map based on Nitrogen removal from grain Protein and yield from 1999.

Spraying Date: June 30th, 2000
Chemicals used:
Puma Super @ 0.31 l/ac
Curtail M @ 0.8 l/ac

Spraying date: July 25th, 2000
Folicur @ 118.25 ml/ac
Water @ 4.5 US gal/ac

Harvested: September 14th, 2000

Field 8:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 20th, 2000
Seeding rate: 120 lbs/ac

P - Fertilizer used: 12-51-0
Application rate: Side-banded @ 59 lbs of product/ac or 30 lbs actual P/ac for the whole field

N - Fertilizer used: 28-0-0 Liquid
Treatments per field: 4 (refer to treatment map)
Treatment type: 3 Uniform rate and 1 Variable Rate (N rates calculated using Farm Phase II software)

Application Rates:
Uniform Treatments:
High rate (H): 26.6 Imp gal / ac or 94 lbs of actual N/ac
Medium rate (M): 23.2 Imp gal/ ac or 82.8 lbs of actual N/ac
Low rate (L): 14.8 Imp gal/ac or 52.8 lbs of actual N/ac
Variable Rate (VRA):
Rates varied from 12 Imp gal/ac to 27 Imp gal/ac or 42.8 lbs of N/ac to 96.4 lbs N/ac
Variable rate application map based on Nitrogen removal from grain Protein and yield from 1999.

Spraying Date: June 30th, 2000
Chemicals used:
Puma Super @ 0.31 l/ac
Curtail M @ 0.8 l/ac

Spraying date: July 25th, 2000
Folicur @ 118.25 ml/ac
Water @ 4.5 US gal/ac

Harvested September 15th, 2000

Fall Weed Control:

Fields 1,4,6: September 30, 2000 – 1 L Roundup/ac in 5 Gal Water.
Fields 2,3,5,7,8: October 10, 2000 - 0.45 L/ac 2-4 D Ester 500 in 4.2 gal water.

2001 Precision Farm
Report on Production Practices for 2001.

Field 1:
Seeded to Peas
Variety: Swing
Date seeded: May 4th, 2001
Seeding rate: 112 lbs/ac and 163 lbs/ac
Seeded area per treatment: 20 acres

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 39 lbs of product/ac or 20 lbs actual P/ac for the whole field
Seed innoculant: LiphaTech @ 5 lbs/ac

Spraying Date: May 8th, 2001
Chemicals used:
Roundup Transorb @ 0.5 l/ac
Water 5 Imp gal/ac

Spraying Date: June 4th, 2001
Chemicals used:
Odyssey @ 0.0173 kg/ac
Merge @ 0.5 l/100l sol.
Water @ 10 Imp gal/ac.

Harvested: August 14th, 2001

Field 6:
Seeded to: Peas
Variety: Swing
Date seeded: May 5th, 2001
Seeding rate: 112 lbs/ac and 163 lbs/ac
Seeded area per treatment: 20 acres

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 39 lbs of product / ac or 20 lbs actual P / ac for the whole field
Seed innoculant: LiphaTech @ 5 lbs/ac

Spraying Date: May 8th, 2001
Chemicals used:
Roundup Transorb @ 0.5 l/ac
Water 5 Imp gal/ac

Spraying Date: June 4th, 2001
Chemicals used:
Odyssey @ 0.0173 kg/ac
Merge @ 0.5 l/100l sol.
Water @ 10 Imp gal/ac.

Harvested: August 15th, 2001

Field 3:
Seeded to Canola
Variety: Liberty Link Invigor 2663
Date seeded: May 14th, 2001
Seeding rate: 5.0 lbs/ac

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 57.7 lbs of product/ac for the whole field

S - Fertilizer used: 20.5-0-0-24
Application rate: Side-banded @ 104.2 lbs of product/ac for the whole field

N - Fertilizer used: 28-0-0
7 different N rates were replicated within the field:
Rate 1 (rt1): 60 lbs N/ac
Rate 2 (rt2): 75 lbs N/ac
Rate 3 (rt3): 90 lbs N/ac
Rate 4 (rt4): 105 lbs N/ac
Rate 5 (rt5): 120 lbs N/ac
Rate 6 (rt6): 135 lbs N/ac
Rate 7 (rt7): 150 lbs N/ac

Spraying Date: June 9th, 2001
Chemicals used:
Decis @ 0.05 l/ac
Water @ 10.8 Imp gal/ac

Spraying Date: June 21st, 2001
Chemicals used:
Liberty @ 1.35 L /ac
Select @ 0.026 L /ac
Amigo @ 0.5 L / 100 L of Solution
Water @ 10 Imp gal/ac

Swathed: August 18th, 2001
Harvested: August 31st, 2001

Field 8:
Seeded to Canola
Variety: Liberty Link Invigor 2663
Date seeded: May 14th, 2001
Seeding rate: 5.0 lbs/ac

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 57.7 lbs of product/ac for the whole field

S - Fertilizer used: 20.5-0-0-24
Application rate: Side-banded @ 104.2 lbs of product/ac for the whole field

N - Fertilizer used: 28-0-0
7 different N rates were replicated within the field:
Rate 1 (rt1): 60 lbs N/ac
Rate 2 (rt2): 75 lbs N/ac
Rate 3 (rt3): 90 lbs N/ac
Rate 4 (rt4): 105 lbs N/ac
Rate 5 (rt5): 120 lbs N/ac
Rate 6 (rt6): 135 lbs N/ac
Rate 7 (rt7): 150 lbs N/ac

Spraying Date: June 9th, 2001
Chemicals used:
Decis @ 0.05 l/ac
Water @ 10.8 Imp gal/ac

Spraying Date: June 21st, 2001
Chemicals used:
Liberty @ 1.35 L /ac
Select @ 0.026 L /ac
Amigo @ 0.5 L / 100 L of Solution
Water @ 10 Imp gal/ac

Swathed: August 18th, 2001
Harvested: August 31st, 2001

Field 2:
Seeded to: Wheat
Variety: AC Barrie
Date seeded: May 16th, 2001

Seeding rate: 120 lbs/ac

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 57.7 lbs of product / ac for the whole field

S- Fertilizer used: 20.5-0-0-24
Application rate: Side-banded @ 41.7 lbs of product/ac for the whole field

N - Fertilizer used: 28-0-0 Liquid
7 different N rates were replicated within the field:
Rate 1 (rt1): 55 lbs N/ac
Rate 2 (rt2): 75 lbs N/ac
Rate 3 (rt3): 90 lbs N/ac
Rate 4 (rt4): 105 lbs N/ac
Rate 5 (rt5): 120 lbs N/ac
Rate 6 (rt6): 135 lbs N/ac
Rate 7 (rt7): 150 lbs N/ac

Spraying Date: May 15th, 2001
Chemicals used:
Roundup Transorb @ 0.5 l/ac
Water @ 5 gal/ac

Spraying Date: June 23rd, 2001
Chemicals used:
Curtail M @ 0.8 l/ac
Water @ 10 gal/ac.

Swathed : August 21st, 2001
Harvested: August 28th, 2001

Field 4:
Seeded to: Wheat
Variety: AC Barrie
Date seeded: May 17th, 2001
Seeding rate: 120 lbs/ac

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 57.7 lbs of product/ac for the whole field

S- Fertilizer used: 20.5-0-0-24
Application rate: Side-banded @ 41.7 lbs of product/ac for the whole field

N - Fertilizer used: 28-0-0 Liquid
7 different N rates were replicated within the field:
Rate 1 (rt1): 55 lbs N/ac

Rate 2 (rt2): 75 lbs N/ac
Rate 3 (rt3): 90 lbs N/ac
Rate 4 (rt4): 105 lbs N/ac
Rate 5 (rt5): 120 lbs N/ac
Rate 6 (rt6): 135 lbs N/ac
Rate 7 (rt7): 150 lbs N/ac

Spraying Date: May 15th, 2001
Chemicals used:
Roundup Transorb @ 0.5 L/ac
Water @ 5 gal/ac

Spraying Date: June 23rd, 2001
Chemicals used:
Curtail M @ 0.8 L/ac
Water @ 10 gal/ac.

Swathed: August 21st, 2001
Harvested: August 29th, 2001

Field 5:
Seeded to Wheat
Variety: AC Barrie
Date seeded: May 15th, 2001
Seeding rate: 120 lbs/ac

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 57.7 lbs of product / ac for the whole field

S- Fertilizer used: 20.5-0-0-24
Application rate: Side-banded @ 41.7 lbs of product/ac for the whole field

N - Fertilizer used: 28-0-0 Liquid
7 different N rates were replicated within the field:
Rate 1 (rt1): 55 lbs N/ac
Rate 2 (rt2): 75 lbs N/ac
Rate 3 (rt3): 90 lbs N/ac
Rate 4 (rt4): 105 lbs N/ac
Rate 5 (rt5): 120 lbs N/ac
Rate 6 (rt6): 135 lbs N/ac
Rate 7 (rt7): 150 lbs N/ac

Spraying Date: May 15th, 2001
Chemicals used:
Roundup Transorb @ 0.5 L/ac
Water @ 5 gal/ac

Spraying Date: June 23rd, 2001
Chemicals used:
Curtail M @ 0.8 l/ac
Water @ 10 gal/ac.

Swathed: August 21st, 2001
Harvested: August 28th, 2001

Field 7:
Seeded to: Wheat
Variety: AC Barrie
Date seeded: May 16th, 2001
Seeding rate: 120 lbs/ac

P - Fertilizer used: 11-52-0
Application rate: Side-banded @ 57.7 lbs of product / ac for the whole field

S- Fertilizer used: 20.5-0-0-24
Application rate: Side-banded @ 41.7 lbs of product/ac for the whole field

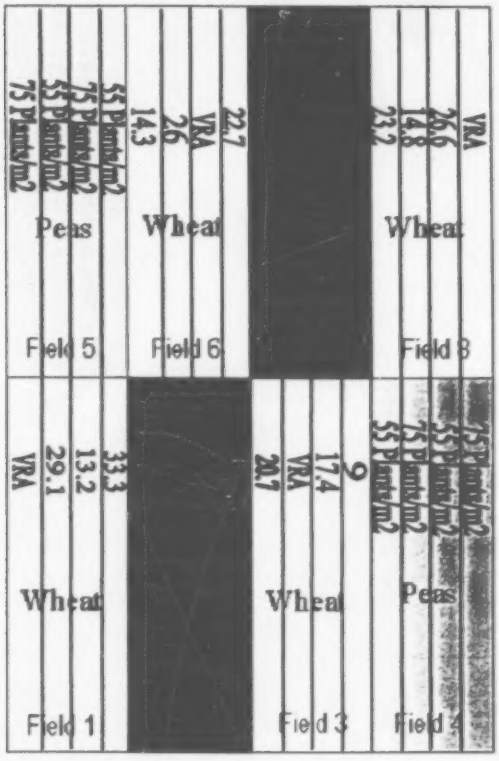
N - Fertilizer used: 28-0-0 Liquid
7 different N rates were replicated within the field :
Rate 1 (rt1): 55 lbs N/ac
Rate 2 (rt2): 75 lbs N/ac
Rate 3 (rt3): 90 lbs N/ac
Rate 4 (rt4): 105 lbs N/ac
Rate 5 (rt5): 120 lbs N/ac
Rate 6 (rt6): 135 lbs N/ac
Rate 7 (rt7): 150 lbs N/ac

Spraying Date: May 15th, 2001
Chemicals used:
Roundup Transorb @ 0.5 l/ac
Water @ 5 gal/ac

Spraying Date: June 23rd, 2001
Chemicals used:
Curtail M @ 0.8 l/ac
Water @ 10 gal/ac.

Swathed: August 21st, 2001
Harvested: August 28th, 2001

Crop Planning for 2000

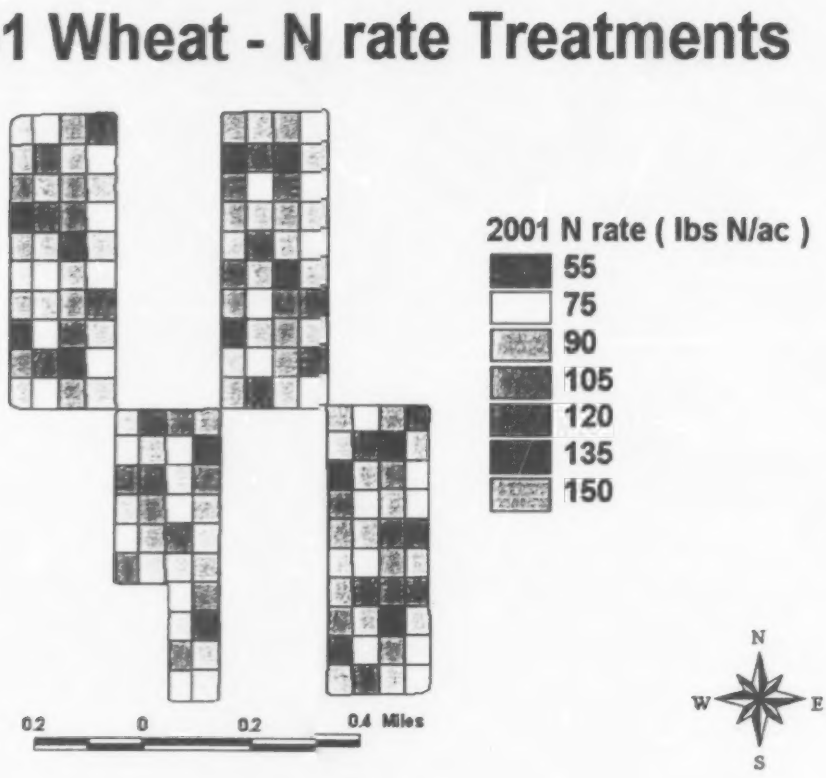


Legend:

All Units are in Imp Gal/ac unless otherwise specified on the map.
Liquid fertilizer used = 28-0-0
There are 3.57 lbs of N/Gal. Imp.
Variable rate nitrogen fertilizer treatments for 2000 Wheat (VRA):
Field 1 = 15 to 37 Imp Gal/ac
Field 3 = 0 to 34 Imp gal/ac
Field 6 = 0 to 30 Imp gal/ac
Field 8 = 12 to 27 Imp gal/ac

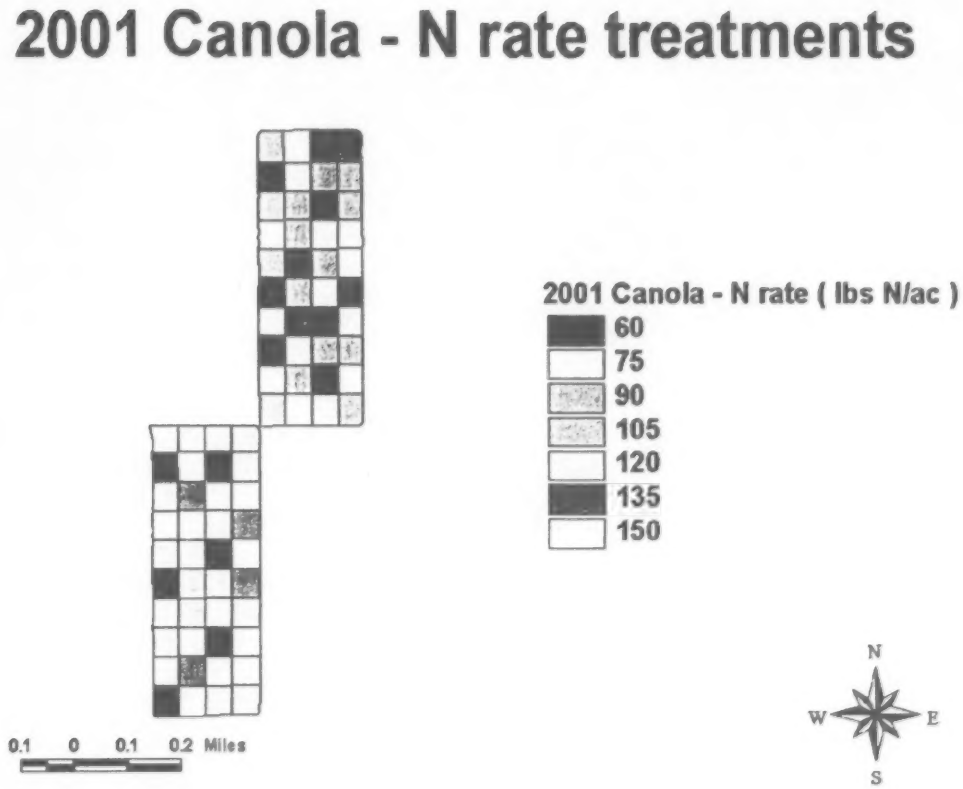
Added fertilizer in all 8 fields: 12-51-0 @ 59 lbs of product/ac

2001 Nitrogen Prescription Map for the Wheat Fields at the IHARF Precision Farm.



Note: Grid cell is equal to 1 acre (43560 square feet)

2001 Nitrogen Prescription Map for the Canola Fields at the IHARF Precision Farm.



Note: Grid cell is equal to 1 acre (43560 square feet)

Appendix C

Input prices and calculations.

2- Cost per acre for all inputs (1998 to 2001).

							Break-Even yield per acre (bu/ac)	
	Mean Yield bu/ac	Grain sale $/bu	Seed Cost $/bu	$/ac of N	$/ac of P	$/ac of S	To cover Variable Expenses	To cover Total Expenses
1998								
Wheat	38.7	3.85	11	19.27	5.33	0	22	35.3
Canola	19.6	7.62	5.5	23.77	5.33	0	11.8	18.5
Peas	41.2	3.28	28.34	0.00	5.33	0	27.3	44.2
1999								
Wheat	50.3	3.07	10.38	26.86	7.28	0	30.5	47.1
Canola	45.1	5.24	8.25	28.66	11.64	0	19.8	29.5
Peas	59.5	3.49	16.86	0.00	7.28	0	22.9	38.8
2000								
Wheat								
f1 l	33.4	3.9	9.82	12.58	8.07	0	20.4	33.5
f1 m	33.4	3.9	9.82	27.71	8.07	0	24.3	37.4
f1 h	33.4	3.9	9.82	31.51	8.07	0	25.3	38.3
f1 r2	33.4	3.9	9.82	24.86	8.07	0	23.6	36.6
f1 r3	33.4	3.9	9.82	26.51	8.07	0	24	37.1
f1 r4	33.4	3.9	9.82	28.03	8.07	0	24.4	37.5
f1 r5	33.4	3.9	9.82	29.74	8.07	0	24.8	37.9
f3 l	30	3.9	9.82	8.57	8.07	0	19.4	32.5
f3 m	30	3.9	9.82	16.58	8.07	0	21.4	34.5
f3 h	30	3.9	9.82	19.73	8.07	0	22.3	35.3
f3 r1	30	3.9	9.82	3.84	8.07	0	18.2	31.2
f3 r2	30	3.9	9.82	5.13	8.07	0	18.5	31.6
f3 r3	30	3.9	9.82	8.45	8.07	0	19.4	32.4
f6 l	38.9	3.9	9.82	13.62	8.07	0	20.7	33.8
f6 m	38.9	3.9	9.82	21.63	8.07	0	22.7	35.8
f6 h	38.9	3.9	9.82	24.78	8.07	0	23.5	36.6
f6 r1	38.9	3.9	9.82	3.03	8.07	0	18	31
f6r2	38.9	3.9	9.82	6.37	8.07	0	18.8	31.9
f8 l	39.8	3.9	9.82	14.10	8.07	0	20.8	33.9
f8 m	39.8	3.9	9.82	22.11	8.07	0	22.9	35.9
f8 h	39.8	3.9	9.82	25.10	8.07	0	23.6	36.7
f8 r2	39.8	3.9	9.82	16.69	8.07	0	21.5	34.5
f8 r3	39.8	3.9	9.82	18.62	8.07	0	22	35
f8 r4	39.8	3.9	9.82	20.29	8.07	0	22.4	35.5
f8 r5	39.8	3.9	9.82	22.15	8.07	0	22.9	35.9

Canola								
f2 l	43.1	4.83	11	19.01	8.07	3.56	20.1	30.6
f2 m	43.1	4.83	11	25.69	8.07	3.56	21.4	32
f2 h1	43.1	4.83	11	30.22	8.07	3.56	22.4	32.9
f2 h2	43.1	4.83	11	31.83	8.07	3.56	22.7	33.3
f2 Uniform	43.1	4.83	11	25.63	8.07	3.56	21.4	32
f7 l	48.58	4.83	11	20.29	8.07	3.56	20.3	30.9
f7 m	48.58	4.83	11	25.90	8.07	3.56	21.5	32
f7 h	48.58	4.83	11	30.97	8.07	3.56	22.5	33.1
f7 Uniform	48.58	4.83	11	25.37	8.07	3.56	21.4	31.9
Peas								
LSR	59.1	3.75	13.425	0.00	8.07	0	20.6	35.4
HSR	59.1	3.75	21.48	0.00	8.07	0	22.7	37.6
2001								
Wheat								
r1	F2 = 30.2	3.66	11.7	11.78	8.07	2.5	22.7	36.7
r2		3.66	11.7	17.62	8.07	2.5	24.3	38.3
r3	F4= 32.5	3.66	11.7	22.00	8.07	2.5	25.5	39.5
r4		3.66	11.7	26.37	8.07	2.5	26.7	40.7
r5	F5= 28.26	3.66	11.7	30.75	8.07	2.5	27.9	41.8
r6		3.66	11.7	35.13	8.07	2.5	29.1	43
r7	F7= 33	3.66	11.7	39.51	8.07	2.5	30.3	44.2
Canola								
r1	F3= 37.9	7.33	11	9.49	8.07	6.25	12.3	19.2
r2		7.33	11	13.86	8.07	6.25	12.9	19.8
r3	F8= 30.8	7.33	11	18.24	8.07	6.25	13.5	20.4
r4		7.33	11	22.62	8.07	6.25	14.1	21
r5		7.33	11	27.00	8.07	6.25	14.7	21.6
r6		7.33	11	31.38	8.07	6.25	15.3	22.2
r7		7.33	11	35.76	8.07	6.25	15.9	22.8
Peas								
LSR	28.8	5.92	10.12	0	8.07	0	12.5	21.9
HSR	28.8	5.92	15.18	0	8.07	0	13.3	22.7

M121

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

Micromedia
ProQuest

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 1998

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	31.4	27.60	20.00
Est. On Farm Market Price/bus,lb (B)	3.55	4.50	7.95
Estimated Gross Revenue/ac (AxB) (C)	**111.47**	**124.20**	**159.00**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	6.88	22.10	6.00
Fertilizer - Nitrogen	14.40	4.80	14.40
- Phosphorus	8.40	8.40	8.40
- Sulfur & Other	0.00	0.00	5.40
Chemical - Herbicides	18.73	29.80	19.25
- Insecticides/Fungicides	2.40	0.00	1.27
- Others	1.65	3.23	3.24
Machinery Operating - Fuel	5.18	5.92	5.55
- Repair	8.00	9.60	8.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	4.24	6.28	6.12
Utilities & Miscellaneous	3.02	3.02	3.02
Interest on Variable Expenses	2.57	3.12	2.76
Total Variable Expenses (D)	**81.72**	**99.28**	**87.65**
Other Expenses/acre			
Building Repair	1.65	1.65	1.65
Property Taxes	4.75	4.75	4.75
Insurance & Licences	2.02	2.02	2.02
Machinery Depreciation	16.00	16.00	16.00
Building Depreciation	1.65	1.65	1.65
Machinery Investment	8.40	10.20	8.40
Building Investment	1.98	1.98	1.98
Land Investment	28.00	28.00	28.00
Total Other Expenses (E)	**64.45**	**66.25**	**64.45**
Labour and Management (F)**	24.07	24.07	24.07
Total Expenses (D+E+F) (G)	**170.24**	**189.60**	**176.17**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**29.75**	**24.92**	**71.35**
Return over Total Expenses (C-G)	**-58.77**	**-65.40**	**-17.17**
BREAK-EVEN YIELD PER ACRE ***			
To Cover Variable Expenses	**23.0**	**22.1**	**11.0**
To Cover Total Expenses	**48.0**	**42.1**	**22.2**
BREAK-EVEN PRICE PER BUS/LB ***			
To Cover Variable Expenses	**2.60**	**3.60**	**4.38**
To Cover Total Expenses	**5.42**	**6.87**	**8.81**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses.

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 1998

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	31.4	27.60	20.00
Est. On Farm Market Price/bus,lb (B)	3.55	4.50	7.95
Estimated Gross Revenue/ac (AxB) (C)	**111.47**	**124.20**	**159.00**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	6.88	22.10	6.00
Fertilizer - Nitrogen	14.40	4.80	14.40
- Phosphorus	8.40	8.40	8.40
- Sulfur & Other	0.00	0.00	5.40
Chemical - Herbicides	18.73	29.80	19.25
- Insecticides/Fungicides	2.40	0.00	1.27
- Others	1.65	3.23	3.24
Machinery Operating - Fuel	5.18	5.92	5.55
- Repair	8.00	9.60	8.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	4.24	6.28	6.12
Utilities & Miscellaneous	3.02	3.02	3.02
Interest on Variable Expenses	2.57	3.12	2.76
Total Variable Expenses (D)	**81.72**	**99.28**	**87.65**
Other Expenses/acre			
Building Repair	1.65	1.65	1.65
Property Taxes	4.75	4.75	4.75
Insurance & Licences	2.02	2.02	2.02
Machinery Depreciation	16.00	16.00	16.00
Building Depreciation	1.65	1.65	1.65
Machinery Investment	8.40	10.20	8.40
Building Investment	1.98	1.98	1.98
Land Investment	28.00	28.00	28.00
Total Other Expenses (E)	**64.45**	**66.25**	**64.45**
Labour and Management (F)**	24.07	24.07	24.07
Total Expenses (D+E+F) (G)	**170.24**	**189.60**	**176.17**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**29.75**	**24.92**	**71.35**
Return over Total Expenses (C-G)	**-58.77**	**-65.40**	**-17.17**
BREAK-EVEN YIELD PER ACRE ***			
To Cover Variable Expenses	**23.0**	**22.1**	**11.0**
To Cover Total Expenses	**48.0**	**42.1**	**22.2**
BREAK-EVEN PRICE PER BUS/LB ***			
To Cover Variable Expenses	**2.60**	**3.60**	**4.38**
To Cover Total Expenses	**5.42**	**6.87**	**8.81**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses.

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 1999

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	32.4	26.70	20.90
Est. On Farm Market Price/bus,lb (B)	4.03	3.26	7.48
Estimated Gross Revenue/ac (AxB) (C)	**130.57**	**87.04**	**156.33**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	6.49	18.00	9.00
Fertilizer - Nitrogen	14.40	1.44	14.40
- Phosphorus	9.00	7.50	9.00
- Sulfur & Other	0.00	0.00	6.60
Chemical - Herbicides	19.20	29.91	22.28
- Insecticides/Fungicides	2.11	0.00	1.31
- Others	1.80	3.60	3.24
Machinery Operating - Fuel	4.48	5.12	4.80
- Repair	7.00	10.20	7.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	2.90	4.62	4.96
Utilities & Miscellaneous	3.14	3.14	3.14
Interest on Variable Expenses	2.69	3.03	3.15
Total Variable Expenses (D)	**79.45**	**89.56**	**93.13**
Other Expenses/acre			
Building Repair	1.60	1.60	1.60
Property Taxes	4.90	4.90	4.90
Insurance & Licences	1.94	1.94	1.94
Machinery Depreciation	14.00	17.00	14.00
Building Depreciation	1.60	1.60	1.60
Machinery Investment	9.80	11.90	9.80
Building Investment	2.24	2.24	2.24
Land Investment	28.00	28.00	28.00
Total Other Expenses (E)	**64.08**	**69.18**	**64.08**
Labour and Management (F)**	31.89	31.89	31.89
Total Expenses (D+E+F) (G)	**175.42**	**190.63**	**189.11**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**51.12**	**-2.51**	**63.20**
Return over Total Expenses (C-G)	**-44.85**	**-103.59**	**-32.77**
BREAK-EVEN YIELD PER ACRE ***			
To Cover Variable Expenses	**19.7**	**27.5**	**12.5**
To Cover Total Expenses	**43.5**	**58.5**	**25.3**
BREAK-EVEN PRICE PER BUS/LB ***			
To Cover Variable Expenses	**2.45**	**3.35**	**4.46**
To Cover Total Expenses	**5.41**	**7.14**	**9.05**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses.

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 2000

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	33	27.30	21.60
Est. On Farm Market Price/bus,lb (B)	3	3.15	4.50
Estimated Gross Revenue/ac (AxB) (C)	**99.00**	**86.00**	**97.20**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	6.14	16.20	12.00
Fertilizer - Nitrogen	13.20	1.32	13.20
- Phosphorus	8.10	6.75	8.10
- Sulfur & Other	0.00	2.70	5.40
Chemical - Herbicides	19.61	26.10	22.65
- Insecticides/Fungicides	1.97	0.00	1.28
- Others	1.88	3.60	3.24
Machinery Operating - Fuel	5.74	6.56	6.15
- Repair	7.00	10.20	7.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	3.16	3.27	4.91
Utilities & Miscellaneous	3.14	3.14	3.14
Interest on Variable Expenses	2.86	3.11	3.42
Total Variable Expenses (D)	**79.04**	**85.95**	**94.75**
Other Expenses/acre			
Building Repair	1.60	1.60	1.60
Property Taxes	4.97	4.97	4.97
Insurance & Licences	2.04	2.04	2.04
Machinery Depreciation	14.00	17.00	14.00
Building Depreciation	1.60	1.60	1.60
Machinery Investment	10.50	12.75	10.50
Building Investment	2.40	2.40	2.40
Land Investment	17.33	17.33	17.33
Total Other Expenses (E)	**54.44**	**59.69**	**54.44**
Labour and Management (F)**			
Total Expenses (D+E+F) (G)	**133.48**	**145.64**	**149.19**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**19.96**	**0.05**	**2.45**
Return over Total Expenses (C-G)	**-34.48**	**-59.64**	**-51.99**
BREAK-EVEN YIELD PER ACRE ***			
To Cover Variable Expenses	**26.3**	**27.3**	**21.1**
To Cover Total Expenses	**44.5**	**46.2**	**33.2**
BREAK-EVEN PRICE PER BUS/LB ***			
To Cover Variable Expenses	**2.40**	**3.15**	**4.39**
To Cover Total Expenses	**4.04**	**5.33**	**6.91**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses.

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 1999

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	32.4	26.70	20.90
Est. On Farm Market Price/bus,lb (B)	4.03	3.26	7.48
Estimated Gross Revenue/ac (AxB) (C)	**130.57**	**87.04**	**156.33**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	6.49	18.00	9.00
Fertilizer - Nitrogen	14.40	1.44	14.40
- Phosphorus	9.00	7.50	9.00
- Sulfur & Other	0.00	0.00	6.60
Chemical - Herbicides	19.20	29.91	22.28
- Insecticides/Fungicides	2.11	0.00	1.31
- Others	1.80	3.60	3.24
Machinery Operating - Fuel	4.48	5.12	4.80
- Repair	7.00	10.20	7.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	2.90	4.62	4.96
Utilities & Miscellaneous	3.14	3.14	3.14
Interest on Variable Expenses	2.69	3.03	3.15
Total Variable Expenses (D)	**79.45**	**89.56**	**93.13**
Other Expenses/acre			
Building Repair	1.60	1.60	1.60
Property Taxes	4.90	4.90	4.90
Insurance & Licences	1.94	1.94	1.94
Machinery Depreciation	14.00	17.00	14.00
Building Depreciation	1.60	1.60	1.60
Machinery Investment	9.80	11.90	9.80
Building Investment	2.24	2.24	2.24
Land Investment	28.00	28.00	28.00
Total Other Expenses (E)	**64.08**	**69.18**	**64.08**
Labour and Management (F)**	31.89	31.89	31.89
Total Expenses (D+E+F) (G)	**175.42**	**190.63**	**189.11**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**51.12**	**-2.51**	**63.20**
Return over Total Expenses (C-G)	**-44.85**	**-103.59**	**-32.77**
BREAK-EVEN YIELD PER ACRE * **			
To Cover Variable Expenses	**19.7**	**27.5**	**12.5**
To Cover Total Expenses	**43.5**	**58.5**	**25.3**
BREAK-EVEN PRICE PER BUS/LB * **			
To Cover Variable Expenses	**2.45**	**3.35**	**4.46**
To Cover Total Expenses	**5.41**	**7.14**	**9.05**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses.

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 2000

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	33	27.30	21.60
Est. On Farm Market Price/bus,lb (B)	3	3.15	4.50
Estimated Gross Revenue/ac (AxB) (C)	**99.00**	**86.00**	**97.20**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	6.14	16.20	12.00
Fertilizer - Nitrogen	13.20	1.32	13.20
- Phosphorus	8.10	6.75	8.10
- Sulfur & Other	0.00	2.70	5.40
Chemical - Herbicides	19.61	26.10	22.65
- Insecticides/Fungicides	1.97	0.00	1.28
- Others	1.88	3.60	3.24
Machinery Operating - Fuel	5.74	6.56	6.15
- Repair	7.00	10.20	7.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	3.16	3.27	4.91
Utilities & Miscellaneous	3.14	3.14	3.14
Interest on Variable Expenses	2.86	3.11	3.42
Total Variable Expenses (D)	**79.04**	**85.95**	**94.75**
Other Expenses/acre			
Building Repair	1.60	1.60	1.60
Property Taxes	4.97	4.97	4.97
Insurance & Licences	2.04	2.04	2.04
Machinery Depreciation	14.00	17.00	14.00
Building Depreciation	1.60	1.60	1.60
Machinery Investment	10.50	12.75	10.50
Building Investment	2.40	2.40	2.40
Land Investment	17.33	17.33	17.33
Total Other Expenses (E)	**54.44**	**59.69**	**54.44**
Labour and Management (F)**			
Total Expenses (D+E+F) (G)	**133.48**	**145.64**	**149.19**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**19.96**	**0.05**	**2.45**
Return over Total Expenses (C-G)	**-34.48**	**-59.64**	**-51.99**
BREAK-EVEN YIELD PER ACRE ***			
To Cover Variable Expenses	**26.3**	**27.3**	**21.1**
To Cover Total Expenses	**44.5**	**46.2**	**33.2**
BREAK-EVEN PRICE PER BUS/LB ***			
To Cover Variable Expenses	**2.40**	**3.15**	**4.39**
To Cover Total Expenses	**4.04**	**5.33**	**6.91**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses.

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 2001

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	33.8	27.90	22.00
Est. On Farm Market Price/bus,lb (B)	4.25	3.00	5.25
Estimated Gross Revenue/ac (AxB) (C)	**143.65**	**83.70**	**115.50**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	7.31	14.40	12.00
Fertilizer - Nitrogen	18.00	1.80	18.00
- Phosphorus	7.80	6.50	7.80
- Sulfur & Other	0.00	0.00	4.00
Chemical - Herbicides	19.46	21.69	21.32
- Insecticides/Fungicides	1.96	0.00	1.22
- Others	1.88	3.60	3.24
Machinery Operating - Fuel	7.00	8.00	7.50
- Repair	7.00	10.20	7.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	1.73	2.51	2.10
Utilities & Miscellaneous	3.86	3.86	3.86
Interest on Variable Expenses	3.08	2.83	3.46
Total Variable Expenses (D)	**85.33**	**78.39**	**95.75**
Other Expenses/acre			
Building Repair	1.60	1.60	1.60
Property Taxes	5.03	5.03	5.03
Insurance & Licences	2.04	2.04	2.04
Machinery Depreciation	14.00	17.00	14.00
Building Depreciation	1.60	1.60	1.60
Machinery Investment	10.50	12.75	10.50
Building Investment	2.40	2.40	2.40
Land Investment	17.33	17.33	17.33
Total Other Expenses (E)	**54.50**	**59.75**	**54.50**
Labour and Management (F)**			
Total Expenses (D+E+F) (G)	**139.83**	**138.14**	**150.25**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**58.32**	**5.31**	**19.75**
Return over Total Expenses (C-G)	**3.82**	**-54.44**	**-34.75**
BREAK-EVEN YIELD PER ACRE * **			
To Cover Variable Expenses	**20.1**	**26.1**	**18.2**
To Cover Total Expenses	**32.9**	**46.0**	**28.6**
BREAK-EVEN PRICE PER BUS/LB * **			
To Cover Variable Expenses	**2.52**	**2.81**	**4.35**
To Cover Total Expenses	**4.14**	**4.95**	**6.83**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses

CROP PRODUCTION COSTS ($/ACRE) BLACK SOIL ZONE 2001

	Direct Seeded Stubble Crops		
	Spring Wheat	Feed Peas	Canola
REVENUE PER ACRE			
Estimated Yield (bu/ac,lb/ac) (A)	33.8	27.90	22.00
Est. On Farm Market Price/bus,lb (B)	4.25	3.00	5.25
Estimated Gross Revenue/ac (AxB) (C)	**143.65**	**83.70**	**115.50**
EXPENSES PER ACRE			
Variable Expenses/acre			
Seed	7.31	14.40	12.00
Fertilizer - Nitrogen	18.00	1.80	18.00
- Phosphorus	7.80	6.50	7.80
- Sulfur & Other	0.00	0.00	4.00
Chemical - Herbicides	19.46	21.69	21.32
- Insecticides/Fungicides	1.96	0.00	1.22
- Others	1.88	3.60	3.24
Machinery Operating - Fuel	7.00	8.00	7.50
- Repair	7.00	10.20	7.00
Custom Work & Hired Labour	6.25	3.00	4.25
Crop Insurance Premium	1.73	2.51	2.10
Utilities & Miscellaneous	3.86	3.86	3.86
Interest on Variable Expenses	3.08	2.83	3.46
Total Variable Expenses (D)	**85.33**	**78.39**	**95.75**
Other Expenses/acre			
Building Repair	1.60	1.60	1.60
Property Taxes	5.03	5.03	5.03
Insurance & Licences	2.04	2.04	2.04
Machinery Depreciation	14.00	17.00	14.00
Building Depreciation	1.60	1.60	1.60
Machinery Investment	10.50	12.75	10.50
Building Investment	2.40	2.40	2.40
Land Investment	17.33	17.33	17.33
Total Other Expenses (E)	**54.50**	**59.75**	**54.50**
Labour and Management (F)**			
Total Expenses (D+E+F) (G)	**139.83**	**138.14**	**150.25**
RETURNS PER ACRE			
Return over Variable Expenses (C-D)	**58.32**	**5.31**	**19.75**
Return over Total Expenses (C-G)	**3.82**	**-54.44**	**-34.75**
BREAK-EVEN YIELD PER ACRE ***			
To Cover Variable Expenses	**20.1**	**26.1**	**18.2**
To Cover Total Expenses	**32.9**	**46.0**	**28.6**
BREAK-EVEN PRICE PER BUS/LB ***			
To Cover Variable Expenses	**2.52**	**2.81**	**4.35**
To Cover Total Expenses	**4.14**	**4.95**	**6.83**

**These budgets do not include an estimate for owner/operator labour and management. This value varies greatly and depends on both the farm manager's needs as well as the ability of the farm business to generate income. Farm managers need to determine their own actual labour and management cost and add it to total expenses.

***The break-even yields and prices for summerfallow crops include the previous years tillage fallow expenses.

IHARF Precision Farm Activities 2001
Disease rating for all fields.

Dr. Bruce Gossen, Ken Bassendowski, AAFC Saskatoon, SK.

Materials and Methods:

Eight fields (approximately 40 acres each) were rated for disease during the 2001 crop year. There were two fields of pea, two of canola and four of wheat. There were 40 sites in each field (except field 1 (pea) which had 36 sites and field 2 (wheat) which had 32 sites) marked by large stakes. At each of the 40 sites within each field, the crop was assessed for disease incidence and severity.

Pea plants were rated for foliar and stem severity caused by Mycosphaerella blight (*Mycosphaerella pinodes*) at 4 spots (5 plants/spot) around each stake using the Xue et al.,1997 0-9 scale. The pea plants were rated on Aug. 13, 2001 and were at a mature (ripe) stage. In fact, they were harvested the next day after disease assessments and samples were taken.

Wheat plants were rated for foliar diseases caused by leaf spot, leaf stripe, rust plus glume blotch. Whole plant disease ratings were done at 4 spots around each stake using the Horsfall-Barratt disease rating (0-11) scale. Wheat plants were rated on Aug. 13, 14, 2001 and were at the dough stage (starting to ripen).

Canola plants were rated for disease severity (foliar, stem, and pods, on a whole plant basis) at 4 spots around each stake using the Horsfall-Barratt disease rating (0-11) scale. Alternaria pod spot (*Alternaria* spp.) was also rated for disease severity at 4 spots around each stake using the Horsfall-Barratt rating scale. Blackleg (*Leptosphaeruia maculans*) and sclerotinia (*Sclerotinia sclerotiorum*) lesions that occurred on any part of the canola stem were assessed separately from basal stem cankers. The number of plants with stem or basal lesions of both blackleg and sclerotinia were noted between 2 x 20 ft.? (length of distance between swaths). The prevalence of staghead (*Albugo candida*) and aster yellows (mycoplasma) were also noted. Canola plants were rated Aug. 23, 2001 after the crop had been swathed (Aug. 18, 19, 2001).

The percent disease for each crop was calculated from Horsfall-Barratt ratings and averaged for each site within the field.

Results and Discussion:

Pea

Mycosphaerella was observed on all pea plants that were rated in fields 1 and 6. Foliar disease severity values ranged from 0.8 to 5.5 in field #1 with an average rating of 4.0 and ranged from 3.5 to 6.8 in field # 6 with an average rating of 5.0.

Wheat

The H-B disease ratings for plants in the four wheat fields ranged from 3.75 to 6.75, 5.25 to 7, 3.75 to 7.25, and 4 to 6.75 for field numbers 5, 2, 7 and 4, respectively. Disease incidence ranged from 16-77% with a mean of 42% for field #5, 44-79% with a mean of 62% for field #2, 19-81% with a mean of 44% for field #7, and 19-77% with a mean of 50% for field #4. There was also a small amount of ergot observed in the fields and a lot of sawfly damage to the wheat.

Canola

Sclerotinia stem rot, blackleg, aster yellows and alternaria pod spot were the most prevalent diseases and in that order of occurrence. Staghead was very rarely found.

The prevalence of sclerotinia stem infested sites was 100% in field #3 and 98% in field # 8. The prevalence of sclerotinia basal infested sites was 48% in field #3 and 30% in field # 8.

Blackleg basal cankers were observed at 58% of the sites in field #3 and 28% of the sites in field #8. The prevalence of blackleg stem lesions was observed at 65% of the sites in field # 3 and 48% in field #8.

Aster yellows occurred at 23 % of the sites in field #3 and 10% of the sites in field #8.

Although the prevalence of sclerotinia and blackleg was high, the incidence of disease of the whole plants ranged from 3-8% in field #3 and 2-8% in field # 8. The severity of alternaria pod spot was also low, at 1-2% in field #3 and 1-3% in field #8.

Field #	Plot/Pin #	Crop	Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg* (basal)	Blackleg* (stem)	Aster Yellows*	Sclerotinia* (stem)	Sclerotinia* (basal)
			1	2	3	4	Avg	1	2	3	4	Avg					
1	1	Peas**	1	1	0	1	0.75										
1	2	Peas	1	4	4	4	3.25										
1	3	Peas	4	3	2	1	2.5										
1	4	Peas	4	3	5	3	3.75										
1	5	Peas	3	1	4	5	3.25										
1	6	Peas	4	4	5	5	4.5										
1	7	Peas	4	4	5	4	4.25										
1	8	Peas	2	1	4	1	2										
1	9	Peas	4	3	1	2	2.5										
1	10	Peas	4	4	1	0	2.25										
5	11	Wheat	5	4	5	6	5										
5	12	Wheat	3	5	5	4	4.25										
5	13	Wheat	4	5	4	4	4.25										
5	14	Wheat	4	4	4	4	4										
5	15	Wheat	4	8	6	6	6										
5	16	Wheat	7	7	7	6	6.75										
5	17	Wheat	7	6	7	6	6.5										
5	18	Wheat	6	5	5	7	5.75										
5	19	Wheat	6	6	4	5	5.25										
5	20	Wheat	5	5	5	5	5										
1	21	Peas	4	5	6	4	4.75										
1	22	Peas	4	4	3	6	4.25										
1	23	Peas	4	4	7	5	5										
1	24	Peas	4	4	6	4	4.5										
1	25	Peas	4	3	6	7	5										
1	26	Peas	3	5	3	4	3.75										
1	27	Peas	4	5	4	6	4.75										
1	28	Peas	4	5	3	4	4										
1	29	Peas	4	4	1	7	4										
1	30	Peas	4	4	7	5	5										
5	31	Wheat	4	3	4	4	3.75										
5	32	Wheat	4	4	6	5	4.75										
5	33	Wheat	4	3	5	4	4										
5	34	Wheat	4	5	5	4	4.5										
5	35	Wheat	5	6	5	5	5.25										
5	36	Wheat	3	5	3	4	3.75										
5	37	Wheat	6	5	5	5	5.25										
5	38	Wheat	6	7	6	6	6.25										
5	39	Wheat	5	6	4	6	5.25										
5	40	Wheat	6	5	7	6	6										

Field #	Plot/Pin #	Crop	Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg* (basal)	Blackleg* (stem)	Aster Yellows*	Sclerotinia* (stem)	Sclerotinia* (basal)
			1	2	3	4	Avg	1	2	3	4	Avg					
1	41	Peas	5	6	4	5	5										
1	42	Peas	3	3	4	4	3.5										
1	43	Peas	5	6	5	4	5										
1	44	Peas	5	3	5	3	4										
1	45	Peas	3	3	4	5	3.75										
1	46	Peas	2	3	3	4	3										
1	47	Peas	4	5	2	3	3.5										
1	48	Peas	3	2	4	5	3.5										
1	49	Peas	4	4	5	4	4.25										
1	50	Peas	4	6	4	7	5.25										
5	51	Wheat	5	4	6	5	5										
5	52	Wheat	4	4	5	5	4.5										
5	53	Wheat	4	4	4	5	4.25										
5	54	Wheat	6	5	4	6	5.25										
5	55	Wheat	4	4	5	5	4.5										
5	56	Wheat	4	5	4	5	4.5										
5	57	Wheat	6	4	4	4	4.5										
5	58	Wheat	5	4	4	6	4.75										
5	59	Wheat	5	4	5	5	4.75										
5	60	Wheat	5	4	5	5	4.75										
1	61	Peas	5	3	6	5	4.75										
1	62	Peas	4	4	5	3	4										
1	63	Peas	4	5	4	4	4.25										
1	64	Peas	4	5	5	7	5.25										
1	65	Peas	4	3	5	4	4										
1	66	Peas	7	5	5	5	5.5										
5	67	Wheat	6	6	6	6	6										
5	68	Wheat	7	6	6	7	6.5										
5	69	Wheat	6	5	6	4	5.25										
5	70	Wheat	4	4	4	5	4.25										
5	71	Wheat	3	4	5	5	4.25										
5	72	Wheat	6	4	5	5	5										
5	73	Wheat	5	6	6	6	5.75										
5	74	Wheat	6	5	5	6	5.5										
5	75	Wheat	7	6	5	7	6.25										
5	76	Wheat	8	7	6	5	6.5										
2	77	Wheat	7	6	6	7	6.5										
2	78	Wheat	6	6	7	7	6.5										
2	79	Wheat	7	8	7	6	7										
2	80	Wheat	6	6	7	7	6.5										

			Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg*	Blackleg*	Aster	Sclerotinia*	Sclerotinia*
Field #	Plot/Pin #	Crop	1	2	3	4	Avg	1	2	3	4	Avg	(basal)	(stem)	Yellows*	(stem)	(basal)
2	81	Wheat	6	5	6	6	5.75										
2	82	Wheat	6	7	7	6	6.5										
6	83	Peas	5	5	4	5	4.75										
6	84	Peas	5	5	4	5	4.75										
6	85	Peas	7	7	5	5	6										
6	86	Peas	7	7	5	5	6										
6	87	Peas	4	6	3	4	4.25										
6	88	Peas	4	7	9	4	6										
6	89	Peas	8	6	5	5	6										
6	90	Peas	4	3	9	5	5.25										
6	91	Peas	5	8	7	7	6.75										
6	92	Peas	3	6	5	4	4.5										
2	93	Wheat	6	6	7	6	6.25										
2	94	Wheat	6	5	5	5	5.25										
2	95	Wheat	5	5	5	6	5.25										
2	96	Wheat	5	5	6	5	5.25										
2	97	Wheat	6	5	5	6	5.5										
2	98	Wheat	7	7	5	6	6.25										
6	99	Peas	4	6	3	6	4.75										
6	100	Peas	2	4	6	5	4.25										
6	101	Peas	6	4	6	7	5.75										
6	102	Peas	6	7	5	5	5.75										
6	103	Peas	7	4	4	5	5										
6	104	Peas	4	6	4	5	4.75										
6	105	Peas	6	4	3	4	4.25										
6	106	Peas	6	7	7	7	6.75										
6	107	Peas	5	5	7	4	5.25										
6	108	Peas	5	4	5	5	4.75										
2	109	Wheat	7	6	7	6	6.5										
2	110	Wheat	6	6	5	7	6										
2	111	Wheat	5	6	6	5	5.5										
2	112	Wheat	6	5	5	6	5.5										
2	113	Wheat	7	7	6	7	6.75										
2	114	Wheat	7	6	6	6	6.25										
2	115	Wheat	5	6	6	5	5.5										
2	116	Wheat	6	8	7	7	7										
2	117	Wheat	7	8	7	6	7										
2	118	Wheat	4	6	6	5	5.25										
6	119	Peas	5	4	4	4	4.25										
6	120	Peas	3	5	5	4	4.25										

Field #	Plot/Pin #	Crop	Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg* (basal)	Blackleg* (stem)	Aster Yellows*	Sclerotinia* (stem)	Sclerotinia* (basal)
			1	2	3	4	Avg	1	2	3	4	Avg					
6	121	Peas	6	5	5	4	5										
6	122	Peas	4	6	5	4	4.75										
6	123	Peas	5	5	5	6	5.25										
6	124	Peas	3	4	5	6	4.5										
6	125	Peas	3	6	6	5	5										
6	126	Peas	4	5	6	6	5.25										
6	127	Peas	4	6	5	6	5.25										
6	128	Peas	5	7	7	4	5.75										
2	129	Wheat	6	5	5	6	5.5										
2	130	Wheat	6	7	6	6	6.25										
2	131	Wheat	6	6	6	5	5.75										
2	132	Wheat	7	6	7	6	6.5										
2	133	Wheat	6	5	6	7	6										
2	134	Wheat	6	6	5	5	5.5										
2	135	Wheat	7	5	5	5	5.5										
2	136	Wheat	7	7	6	6	6.5										
2	137	Wheat	5	6	7	5	5.75										
2	138	Wheat	7	7	6	7	6.75										
6	139	Peas	4	3	6	4	4.25										
6	140	Peas	4	6	6	5	5.25										
6	141	Peas	5	4	7	4	5										
6	142	Peas	4	5	4	6	4.75										
6	143	Peas	7	3	7	3	5										
6	144	Peas	4	5	7	5	5.25										
6	145	Peas	5	5	4	5	4.75										
6	146	Peas	4	4	4	7	4.75										
6	147	Peas	5	1	1	7	3.5										
6	148	Peas	4	5	5	3	4.25										
3	149	Canola	2	2	2	2	2	0	0	0	0	0	1	2	0	4	0
3	150	Canola	3	2	2	1	2	0	0	1	1	0.5	0	0	0	3	0
3	151	Canola	2	1	2	1	1.5	0	0	0	0	0	0	0	0	4	5
3	152	Canola	3	2	2	2	2.25	0	0	0	0	0	3	0	0	5	0
3	153	Canola	3	1	2	1	1.75	0	0	1	0	0.25	0	0	1	4	2
3	154	Canola	2	2	1	1	1.5	0	1	0	1	0.5	0	0	3	6	1
3	155	Canola	1	2	2	1	1.5	0	1	0	0	0.25	0	0	0	3	3
3	156	Canola	1	2	1	2	1.5	0	1	1	1	0.75	0	0	3	5	0
3	157	Canola	2	1	1	2	1.5	0	1	0	0	0.25	0	0	0	5	0
3	158	Canola	3	2	1	2	2	1	0	1	1	0.75	0	2	1	8	0
7	159	Wheat	6	5	5	5	5.25										
7	160	Wheat	5	5	5	4	4.75										

Field #	Plot/Pin #	Crop	Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg* (basal)	Blackleg* (stem)	Aster Yellows*	Sclerotinia* (stem)	Sclerotinia* (basal)
			1	2	3	4	Avg	1	2	3	4	Avg					
7	161	Wheat	4	4	5	6	4.75										
7	162	Wheat	4	4	5	4	4.25										
7	163	Wheat	5	5	5	4	4.75										
7	164	Wheat	4	4	4	4	4										
7	165	Wheat	4	5	5	6	5										
7	166	Wheat	6	6	6	6	6										
7	167	Wheat	5	6	6	6	5.75										
7	168	Wheat	6	4	4	5	4.75										
3	169	Canola	2	2	1	1	1.5	0	0	0	0	0	0	0	0	7	0
3	170	Canola	3	1	2	1	1.75	0	0	0	0	0	2	2	0	5	0
3	171	Canola	3	2	3	1	2.25	0	0	0	0	0	4	1	0	3	2
3	172	Canola	1	2	1	1	1.25	0	0	1	0	0.25	3	1	0	3	2
3	173	Canola	2	1	1	2	1.5	0	1	0	1	0.5	4	4	0	5	3
3	174	Canola	1	1	4	3	2.25	0	0	0	0	0	2	2	2	5	0
3	175	Canola	4	1	2	2	2.25	0	0	0	0	0	2	2	0	8	2
3	176	Canola	3	1	3	3	2.5	0	0	1	0	0.25	1	0	2	3	3
3	177	Canola	1	2	1	3	1.75	1	0	1	1	0.75	0	2	0	6	0
3	178	Canola	2	1	1	2	1.5	0	0	1	0	0.25	2	1	0	3	0
7	179	Wheat	5	6	6	5	5.5										
7	180	Wheat	7	8	6	6	6.75										
7	181	Wheat	5	6	7	6	6										
7	182	Wheat	5	5	4	4	4.5										
7	183	Wheat	5	5	4	6	5										
7	184	Wheat	5	5	5	5	5										
7	185	Wheat	2	4	4	5	3.75										
7	186	Wheat	6	4	4	4	4.5										
7	187	Wheat	4	5	6	5	5										
7	188	Wheat	5	6	6	5	5.5										
3	189	Canola	1	2	2	1	1.5	1	0	0	0	0.25	0	2	0	2	0
3	190	Canola	1	2	1	2	1.5	1	1	0	0	0.5	3	4	0	3	0
3	191	Canola	1	3	2	1	1.75	0	0	0	0	0	3	1	1	2	0
3	192	Canola	2	1	2	2	1.75	1	0	0	0	0.25	3	3	0	4	0
3	193	Canola	3	2	2	1	2	0	0	1	0	0.25	0	0	0	4	0
3	194	Canola	1	2	1	2	1.5	0	0	0	0	0	3	0	0	5	1
3	195	Canola	1	1	2	2	1.5	0	0	0	0	0	0	1	0	7	1
3	196	Canola	1	1	2	1	1.25	0	0	1	0	0.25	1	1	1	5	1
3	197	Canola	1	3	1	1	1.5	0	1	0	0	0.25	1	1	0	4	2
3	198	Canola	1	1	2	1	1.25	0	0	0	0	0	3	0	0	4	1
7	199	Wheat	5	5	5	6	5.25										
7	200	Wheat	4	5	5	4	4.5										

			Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg* (basal)	Blackleg* (stem)	Aster Yellows*	Sclerotinia* (stem)	Sclerotinia* (basal)
Field #	Plot/Pin #	Crop	1	2	3	4	Avg	1	2	3	4	Avg					
7	201	Wheat	5	6	6	6	5.75										
7	202	Wheat	4	5	6	5	5										
7	203	Wheat	5	5	4	5	4.75										
7	204	Wheat	5	6	6	6	5.75										
7	205	Wheat	4	6	5	6	5.25										
7	206	Wheat	4	5	5	5	4.75										
7	207	Wheat	5	5	6	4	5										
7	208	Wheat	4	4	6	6	5										
3	209	Canola	1	1	2	1	1.25	1	0	0	0	0.25	5	5	1	2	0
3	210	Canola	2	1	1	1	1.25	0	0	1	1	0.5	6	5	0	3	0
3	211	Canola	2	1	2	1	1.5	1	0	1	0	0.5	2	1	0	3	0
3	212	Canola	2	3	1	2	2	1	0	1	0	0.5	0	4	0	5	0
3	213	Canola	1	2	1	1	1.25	1	1	0	0	0.5	2	4	0	4	2
3	214	Canola	3	2	2	3	2.5	1	0	0	0	0.25	1	3	0	3	1
3	215	Canola	1	2	2	2	1.75	0	1	0	0	0.25	0	1	0	5	0
3	216	Canola	2	1	2	2	1.75	0	0	0	1	0.25	0	3	0	6	1
3	217	Canola	1	1	2	1	1.25	0	0	1	1	0.5	1	2	0	3	2
3	218	Canola	1	2	2	1	1.5	1	0	0	0	0.25	0	0	0	1	3
7	219	Wheat	6	5	7	5	5.75										
7	220	Wheat	5	5	4	5	4.75										
7	221	Wheat	7	8	8	6	7.25										
7	222	Wheat	6	7	6	5	6										
7	223	Wheat	5	6	7	7	6.25										
7	224	Wheat	6	6	5	6	5.75										
7	225	Wheat	5	5	6	5	5.25										
7	226	Wheat	4	5	4	6	4.75										
7	227	Wheat	5	6	6	5	5.5										
7	228	Wheat	5	5	6	6	5.5										
4	229	Wheat	5	5	6	6	5.5										
4	230	Wheat	5	5	6	4	5										
4	231	Wheat	5	4	5	5	4.75										
4	232	Wheat	5	6	6	7	6										
4	233	Wheat	5	4	6	5	5										
4	234	Wheat	5	5	5	6	5.25										
4	235	Wheat	6	5	6	6	5.75										
4	236	Wheat	6	6	6	7	6.25										
4	237	Wheat	5	6	6	6	5.75										
4	238	Wheat	4	4	4	4	4										
8	239	Canola	1	2	3	1	1.75	1	1	1	1	1	0	1	0	4	0
8	240	Canola	1	3	1	2	1.75	0	0	0	1	0.25	2	1	0	1	0

Field #	Plot/Pin #	Crop	Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg* (basal)	Blackleg* (stem)	Aster Yellows*	Sclerotinia* (stem)	Sclerotinia* (basal)
			1	2	3	4	Avg	1	2	3	4	Avg					
8	241	Canola	1	2	1	2	1.5	0	0	0	0	0	0	1	0	3	1
8	242	Canola	1	2	1	1	1.25	0	0	0	1	0.25	1	2	0	3	0
8	243	Canola	1	2	1	2	1.5	0	0	1	0	0.25	1	3	0	3	1
8	244	Canola	3	2	1	1	1.75	0	0	1	1	0.5	0	0	0	3	0
8	245	Canola	2	1	3	2	2	1	0	1	0	0.5	0	0	0	5	1
8	246	Canola	2	4	2	1	2.25	0	1	1	1	0.75	0	1	1	3	1
8	247	Canola	1	2	1	1	1.25	1	0	1	0	0.5	3	0	0	3	1
8	248	Canola	3	2	1	2	2	2	1	0	0	0.75	0	4	0	2	0
4	249	Wheat	5	4	4	4	4.25										
4	250	Wheat	4	5	4	4	4.25										
4	251	Wheat	4	4	4	5	4.25										
4	252	Wheat	6	5	4	5	5										
4	253	Wheat	6	5	5	4	5										
4	254	Wheat	4	5	4	5	4.5										
4	255	Wheat	5	6	5	5	5.25										
4	256	Wheat	5	5	6	5	5.25										
4	257	Wheat	5	5	5	5	5										
4	258	Wheat	5	4	4	5	4.5										
8	259	Canola	3	1	2	1	1.75	0	0	0	1	0.25	0	0	1	2	0
8	260	Canola	1	1	3	2	1.75	1	0	0	1	0.5	0	0	0	5	0
8	261	Canola	1	1	1	2	1.25	0	0	0	1	0.25	0	0	0	4	0
8	262	Canola	1	2	2	1	1.5	0	0	0	0	0	2	2	0	1	0
8	263	Canola	1	1	1	1	1	1	0	2	0	0.75	1	2	0	1	0
8	264	Canola	1	2	1	1	1.25	0	0	0	1	0.25	0	0	1	0	0
8	265	Canola	1	2	1	2	1.5	0	2	1	0	0.75	0	1	0	1	0
8	266	Canola	1	1	2	1	1.25	1	0	2	1	1	0	0	0	3	0
8	267	Canola	2	1	2	1	1.5	1	0	1	1	0.75	0	0	0	5	0
8	268	Canola	2	1	1	1	1.25	0	1	0	1	0.5	0	3	0	2	1
4	269	Wheat	6	4	5	4	4.75										
4	270	Wheat	5	6	6	5	5.5										
4	271	Wheat	6	6	6	7	6.25										
4	272	Wheat	6	6	5	6	5.75										
4	273	Wheat	6	5	5	5	5.25										
4	274	Wheat	7	6	6	6	6.25										
4	275	Wheat	6	6	6	5	5.75										
4	276	Wheat	5	5	6	5	5.25										
4	277	Wheat	6	6	7	6	6.25										
4	278	Wheat	7	6	6	7	6.5										
8	279	Canola	1	2	1	2	1.5	1	2	2	1	1.5	0	3	0	4	0
8	280	Canola	1	1	2	1	1.25	0	1	1	1	0.75	0	0	0	3	0

Field #	Plot/Pin #	Crop	Horsfall-Barratt ratings					H-B ratings of pod spot					Blackleg* (basal)	Blackleg* (stem)	Aster Yellows*	Sclerotinia* (stem)	Sclerotinia* (basal)
			1	2	3	4	Avg	1	2	3	4	Avg					
8	281	Canola	1	1	1	1	1	1	1	1	0	0.75	0	0	0	6	0
8	282	Canola	2	1	2	1	1.5	0	1	0	1	0.5	0	3	0	4	0
8	283	Canola	1	2	1	1	1.25	0	0	1	0	0.25	0	2	0	3	0
8	284	Canola	1	1	2	1	1.25	0	0	1	0	0.25	1	0	0	2	2
8	285	Canola	1	1	2	2	1.5	0	0	0	0	0	0	0	0	2	0
8	286	Canola	2	2	2	1	1.75	2	1	0	0	0.75	0	1	0	5	0
8	287	Canola	1	2	1	2	1.5	0	0	0	2	0.5	0	0	0	4	1
8	288	Canola	1	3	2	1	1.75	0	0	0	0	0	0	5	0	5	1
4	289	Wheat	6	5	5	6	5.5										
4	290	Wheat	5	6	7	5	5.75										
4	291	Wheat	6	6	6	5	5.75										
4	292	Wheat	5	7	7	6	6.25										
4	293	Wheat	6	6	6	7	6.25										
4	294	Wheat	6	7	6	7	6.5										
4	295	Wheat	7	7	6	6	6.5										
4	296	Wheat	7	7	6	7	6.75										
4	297	Wheat	7	6	6	6	6.25										
4	298	Wheat	7	6	6	8	6.75										
8	299	Canola	2	1	1	2	1.5	0	1	0	0	0.25	0	1	0	3	2
8	300	Canola	1	1	2	2	1.5	2	1	0	1	1	1	0	0	3	2
8	301	Canola	1	1	2	1	1.25	1	1	1	0	0.75	2	0	0	4	0
8	302	Canola	1	2	2	1	1.5	0	0	1	0	0.25	1	1	0	4	0
8	303	Canola	1	1	1	2	1.25	0	0	0	0	0	0	0	0	2	0
8	304	Canola	1	2	2	2	1.75	0	0	0	0	0	0	0	0	2	0
8	305	Canola	1	2	1	2	1.5	0	0	0	0	0	0	0	1	3	0
8	306	Canola	1	1	1	1	1	0	0	1	0	0.25	0	0	0	3	1
8	307	Canola	2	2	1	2	1.75	0	0	0	1	0.25	0	0	0	3	0
8	308	Canola	1	2	2	3	2	0	0	0	0	0	1	1	0	4	0

** Peas were rated on the 0-9 scale for peas (Xue et al., 1997)

Wheat diseases - H-B ratings included disease caused by glume blotch, leaf spot, leaf stripe and rust
- there was also some ergot present and a lot of sawfly damage to the wheat

* - number of plants with disease noted in 2 lengths of distance between swaths
1 canola plant with Stagshead disease was found on plot number 261

- Field peas and wheat were rated for disease on Aug. 13/01
- Canola was rated for disease on Aug. 23/01